SOIL SURVEY

Mendota Area California

Series 1940, No. 18

Issued January 1956

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with the
UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

FARMERS who have worked with their soils for a long time know about differences among soils on their own farm, and perhaps about differences among soils on the farms of their immediate neighbors. What they do not know, unless soil surveys have been made, is how nearly their soils are like those on experiment stations or on other farms, either in their State or other States, where farmers have gained experience with new or different farming practices or farm enterprises. Farmers of the Mendota Area can avoid some of the risk and uncertainty involved in trying new crop and soil management practices by using this report, for it maps and describes the soils of their area and therefore allows them to compare soils on their farms with soils on which new developments have proved successful.

SOILS OF A PARTICULAR FARM

All the soils of the Mendota Area are shown on the soil map accompanying this report. In using this map, first locate the boundaries of your farm by referring to roads, streams, dwellings, and other landmarks shown on the map. The next step is to identify the soils on your farm. Suppose, for example, you find on your farm an area marked with the symbol Pe. Look among the colored rectangles in the margin of the map and find the one with Pe printed on it. This identifies Panoche clay loam. All areas of this soil, wherever they appear on the map, have the same symbol and color.

What is Panoche clay loam like; for what is it now used; and how should it be used: For this information turn to the section on Soil Series, Types, and Phases, where each soil is discussed.

How productive is this soil? The answer will be found in the section on Relative Suitability of Soils for Agriculture. In table 7 the suitability of all the soils is given in relative descriptive terms, and in table 8 these terms are converted into yield ranges for principal crops.

SOILS OF THE AREA AS A WHOLE

A general idea of the soils of the area is given in the introductory part of the section on Soils, and in the section on Soils and Their Relations. These sections tell about the principal kinds of soils, where they are found, and how they are related to one another. After reading these sections, study figure 3 on page 21, and notice how the different kinds of soils tend to be arranged in different parts of the area. These patterns are often associated with well-recognized differences in type of farming, land use, and land use problems.

A newcomer to the area, especially if he considers purchasing a farm, will want to know about the climate; land use; the principal farm products and how they are marketed; the kinds and conditions of farm tenure, including tenancy; availability of roads, railroads, electric services, and water supplies; the industries of the area; and cities, villages, and population characteristics. Information about all these will be found in the sections on General Nature of the Area and on Agriculture.

Those interested in how the soils of the area were formed and how they are related to the great soil groups of the world should read the section on Morphology and Genesis of Soils.

This publication on the soil survey of the Mendota Area, Calif., is a cooperative contribution from the—

SOIL CONSERVATION SERVICE

and the

UNIVERSITY OF CALIFORNIA AGRICULTURAL EXPERIMENT STATION

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SOIL SURVEY OF THE MENDOTA AREA, CALIFORNIA

By FRANK F. HARRADINE, in Charge, R. A. GARDNER, L. G. ROOKE, and E. A. KNECHT, University of California

Area inspected by RAY C. ROBERTS, Soil Survey [1]

United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station [2]

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[1] Field work for this survey was done when Soil Survey was part of the Bureau of Plant Industry, Soils, and Agricultural Engineering. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

[2] Approximately 370 square miles in the central part of the Mendota Area were surveyed by the University of California Agricultural Experiment Station in cooperation with the Bureau of Reclamation, United States Department of the Interior.

UNLESS irrigated, the soils of the Mendota Area support only a scant growth of shallow-rooted grasses and shrubs because the rainfall is very low. The early residents were cattlemen and sheepmen who moved their herds about in search of adequate pasture. Early attempts at dry farming were not successful, and no sustained agriculture or settlement was possible before irrigation and transportation facilities were established in the late 1880's. The earlier emphasis was on irrigated grains, especially barley. Cotton, flax, and rice, introduced in the middle 1930's, have changed the crop pattern and given impetus to settlement and improvement of the area. Alfalfa and some truck crops are also grown. Unirrigated lands are grazed almost exclusively by sheep. Three small towns, all located near the eastern border, are supported by the agriculture of the area. Industry is limited to several large cotton gins near Firebaugh and Mendota, a packing shed in Firebaugh, and several welding and tractor repair shops. To provide a basis for determining the best agricultural uses of the land, the cooperative soil survey here reported was made by the United States Department of Agriculture and the University of California Agricultural Experiment Station. Field work was completed in 1940. Unless otherwise mentioned, all statements in this report refer to conditions in the area at that time.

GENERAL NATURE OF THE AREA

LOCATION AND EXTENT

The Mendota Area is in the northwestern part of Fresno County (fig. 1). Sacramento, the State capital, is 140 miles to the northwest, and Los Angeles is 220 miles to the southeast. The area surveyed closely approximates that of Township 1 of Fresno County. It covers a total area of approximately 588 square miles, or 376,320 acres. The longer axis parallels the northwesterly course of the San Joaquin

FIGURE 1.—Location of the Mendota Area in California.

River. The northern boundary is the Merced-Fresno County line, which is also the southern boundary of the soil survey of the Los Banos area (*1*).[3] The southern boundary of the survey is the line between Townships 15 and 16 south. The San Joaquin River marks the north half, and Fresno Slough, from its junction with the San Joaquin, the south half of the eastern boundary. For the most part, the western boundary follows the irregular contour line marking an elevation of 1,000 feet.

[3] Italic numbers in parentheses refer to Literature Cited, p. 96.

Most of the area included in the survey, except along the western foothills, has been covered by the early reconnaissance soil surveys of the San Joaquin Valley (*3*, *8*). A small part along the eastern edge of the area was included in the soil survey of the Fresno area (*13*).

PHYSIOGRAPHY, RELIEF, AND DRAINAGE

The Mendota Area lies within the Great Interior, or Central, Valley, a prominent physiographic division of California. This valley is an elongated trough or basin that extends from above Redding on the north to below Bakersfield on the south, a distance of more than 500 miles. The average width of the valley is 40 miles; its sides parallel the eastern and western boundaries of the State, the trend of direction being northwest-southeast. The valley is enclosed by mountain ranges except for one break on the west side in the Delta Region through which the San Joaquin and Sacramento Rivers find an outlet to San Francisco Bay and the Pacific Ocean. The Great Interior Valley is composed of two parts: (1) The northern and smaller part known as the Sacramento Valley, which is drained by the Sacramento River; and (2) the southern part, called the San Joaquin Valley, which is drained by the San Joaquin River.

The east side of the San Joaquin Valley is bordered by the rugged Sierra Nevada, a mountain range composed largely of granitic materials. These mountains reach elevations of 14,000 feet or more and are the source of several rivers, including the San Joaquin and Kings Rivers, both of which are important to the Mendota Area. The San Joaquin River drains the northern two-thirds of the San Joaquin Valley. From the mountains, it follows a southwesterly course along the northern boundary of Fresno County to the center line of the valley; it then turns sharply northwestward and continues approximately 120 miles to Suisun Bay. The Kings River enters the San Joaquin Valley south of the San Joaquin River and originally emptied into Tulare Lake. At present, however, much of the water in the Kings River is artificially diverted from the drainage area once marked by Tulare Lake into the main drainage system of the San Joaquin River by way of Fresno Slough. This slough is the only drainage outlet for the upper San Joaquin Valley. South of the San Joaquin River, none of the rivers or streams flowing into the San Joaquin Valley reach the main drainage system.

The Coast Range flanking the west side of the valley consists for the most part of low parallel ridges that rarely reach an elevation of 3,000 feet. The ridges are composed almost entirely of sandstones and shales, in places calcareous. The range forms a natural barrier against the coastal winds and fogs and creates a rain shadow, or area of reduced rainfall, on the west side of the San Joaquin Valley. Due to the aridity of the eastern side of the Coast Range, particularly the southern half, only a few intermittent streams, such as Silver, Panoche, and Little Panoche Creeks, enter the San Joaquin Valley after draining the mountain slopes that border the Mendota Area. The combined drainage area of these streams is 646 square miles (*2*). They maintain a relatively low fluctuating and intermittent discharge and over a period of many years have built up a series of large gently sloping alluvial fans. The creeks rarely reach the San Joaquin River drainage system even during flood years. Small levees and shallow ditches have been constructed near the mouths of the creeks to con-

trol annual runoff and to spread it over a wide area. This practice reduces gully erosion on the fans and provides additional soil moisture for dry farming.

The slope in the eastern part of the area is very slightly northward. The relief is almost level, beginning at an elevation of 166 feet at Tranquillity in the southeastern part of the area and continuing 11 miles northwestward to an elevation of 160 feet, 2 miles north of Mendota, where Fresno Slough joins with the San Joaquin River. From Firebaugh, about 8 miles northwest of Mendota and adjacent to the San Joaquin River, where the elevation is 153 feet above sea level, to the Santa Rita Bridge, approximately 16 miles further downstream, the elevation declines to 124 feet. The flat valley basin on the west side of the river is from 2 to 4 miles wide, and to the west it joins the outer edge of the very gently sloping coalescent alluvial fans below the foothills of the Coast Range. The fans maintain an average slope of 1 percent up to an elevation of about 300 feet in most places and up to 400 feet in the vicinity of Panoche Creek. The slope increases noticeably to the 500 foot elevation, and then rises more abruptly to the higher terraces and mountains of the western part of the area.

CLIMATE

The climate of the Mendota Area is arid; the year is divided into two seasons. The hot dry summer extends from April through October. During this time, the average rainfall for the season is less than one-quarter inch (table 1). Temperatures are high during the cloudless midsummer days. For a week or two at a time, maximum daily temperatures range between 100° and 110° F. This extreme heat is bearable because humidity is normally low throughout the dry summer, and nights are usually much cooler.

January, February, and March are usually the wettest months of the year, with a high relative humidity. Temperatures frequently reach the freezing point during the night, and early morning frosts are common. Fogs occur in a short period during the winter, and seldom persist the whole day. Snow, prolonged periods of freezing temperatures, strong winds, or thunderstorms rarely occur.

In general, the rainfall increases to the north and east of the Mendota Area, and decreases towards the south. There is also a greater amount of precipitation at high elevations west of the area than in the valley.[4]

Table 1 gives normal monthly, seasonal, and annual precipitation and temperature at the four U. S. Weather Bureau Stations nearest the Mendota Area.[5] Los Banos is 15 miles to the northwest, Fresno 34

[4] Average annual precipitation at Idria (elevation 3,000 feet) west of the Mendota Area is 13.06 inches, and at Priest Valley (elevation 2,400 feet) to the southwest it is 19.32 inches.

[5] No systematically kept temperature data are available for a point within the Mendota Area, but an average of the normal monthly, seasonal, or annual temperatures given in table 1 for nearby weather stations will closely approximate corresponding temperatures at Firebaugh and Mendota.

miles east, Hanford 45 miles southeast, and Coalinga 48 miles south of the area.

The summers are hot and dry in the central part of the San Joaquin Valley, but the heat is alleviated by the accompanying low relative humidity. Some residents leave the valley during midsummer, when temperatures frequently reach 100° and 110° in the shade.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at four stations near the Mendota Area, Calif.*

COALINGA, ELEVATION, 676 FEET

Month	Temperature [1]			Precipitation [2]		
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
December	47. 0	80	13	1. 26	0. 67	2. 92
January	46. 1	81	11	1. 39	1. 53	1. 70
February	50. 9	90	18	1. 69	1. 16	4. 00
Winter	48. 0	90	11	4. 34	3. 36	8. 62
March	54. 9	89	22	1. 13	. 08	3. 47
April	60. 6	100	28	. 57	. 05	1. 18
May	67. 5	106	29	. 25	. 57	0
Spring	61. 0	106	22	1. 95	. 70	4. 65
June	75. 7	118	35	. 09	(3)	(3)
July	82. 3	120	47	. 06	0	0
August	80. 2	116	33	. 01	0	0
Summer	79. 4	120	33	. 16	(3)	(3)
September	73. 6	111	32	. 06	. 05	0
October	64. 8	108	24	. 26	0	. 64
November	54. 5	91	17	. 46	. 40	. 58
Fall	64. 3	111	17	. 78	. 45	1. 22
Year	63. 2	120	11	7. 23	[4] 4. 51	[5] 14. 49

See footnotes at end of table.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at four stations near the Mendota Area, Calif.*—Con.

FRESNO (AIRPORT), ELEVATION, 331 FEET

Month	Temperature [1]			Precipitation [2]		
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*
December	45.1	76	23	1.45	0.42	3.98
January	45.5	73	17	1.73	.20	2.29
February	50.3	84	24	1.48	.60	3.18
Winter	47.0	84	17	4.66	1.22	9.45
March	54.4	87	28	1.58	.46	2.81
April	60.2	101	34	.95	.41	2.85
May	67.2	110	38	.44	.20	1.11
Spring	60.6	110	28	2.97	1.07	6.77
June	75.7	112	42	.08	.02	1.29
July	81.3	115	50	.01	([3])	0
August	79.5	113	51	.01	([3])	0
Summer	78.8	115	42	.10	.02	1.29
September	72.0	111	42	.21	([3])	0
October	62.3	100	36	.57	.81	.35
November	52.4	86	27	.93	.43	.08
Fall	62.2	111	27	1.71	1.24	10.43
Year	62.2	115	17	9.44	[6] 3.55	[7] 17.94

HANFORD, ELEVATION, 249 FEET

Month	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year
December	45.9	80	18	1.25	0.51	3.11
January	45.4	95	14	1.72	.41	1.51
February	50.5	94	18	1.63	.49	3.90
Winter	47.3	95	14	4.60	1.41	8.52
March	54.7	95	23	1.62	.56	2.05
April	60.7	100	20	.68	.11	2.41
May	67.4	105	30	.31	.41	([3])
Spring	60.9	105	20	2.61	1.08	4.46
June	75.1	114	36	.10	0	([3])
July	80.6	113	44	0	0	0
August	78.5	111	40	.01	0	([3])
Summer	78.1	114	36	.11	0	0
September	72.3	109	35	.18	([3])	0
October	63.1	98	28	.36	.59	.90
November	52.8	94	20	.72	.29	.57
Fall	62.7	109	20	1.26	.88	1.47
Year	62.3	114	14	8.58	[8] 3.37	[9] 14.45

See footnotes at end of table.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at four stations near the Mendota Area, Calif.*—Con.

LOS BANOS, ELEVATION, 125 FEET

Month	Temperature [1]			Precipitation [2]		
	Average	Absolute maximum	Absolute minimum	Average	Total for the driest year	Total for the wettest year
	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*
December	48.0	80	24	1.42	0.65	3.96
January	48.0	81	20	1.73	.96	1.42
February	50.8	77	25	1.37	.25	3.09
Winter	48.9	81	20	4.52	1.86	8.47
March	55.5	80	30	1.36	.16	2.95
April	61.7	98	40	.65	([3])	1.80
May	67.5	100	45	.35	.04	1.03
Spring	61.6	100	30	2.36	.20	5.78
June	74.0	106	52	.06	0	1.37
July	79.5	110	55	.01	0	0
August	78.1	110	56	.01	0	0
Summer	77.2	110	52	.08	0	1.37
September	72.9	106	50	.12	0	0
October	64.6	92	40	.31	0	1.01
November	54.7	84	28	.89	.79	.05
Fall	64.1	106	28	1.38	.79	1.06
Year	62.8	110	20	8.34	[10] 2.85	[11] 16.68

[1] Coalinga: Average temperature based on a 42-year record, 1911 to 1952; highest and lowest temperatures from a 20-year record, 1911 to 1930. Fresno: Average temperature based on a 66-year record, 1887 to 1952; highest and lowest temperatures from a 44-year record, 1887 to 1930. Hanford: Average temperature based on a 54-year record, 1899 to 1952; highest and lowest temperatures from a 32-year record, 1899 to 1930. Los Banos: Average temperature based on a 50-year record, 1903 to 1952; highest and lowest temperatures from an 18-year record, 1913 to 1930.

[2] Coalinga: Average precipitation based on a 42-year record, 1911 to 1952; wettest and driest years based on a 41-year record, 1912 to 1952. Fresno: Average precipitation based on a 76-year record, 1877 to 1952; wettest and driest years based on a 75-year record, 1878 to 1952. Hanford: Average precipitation based on a 54-year record, 1899 to 1952; wettest and driest years based on a 54-year record, 1899 to 1952. Los Banos: Average precipitation based on an 81-year record, 1872 to 1952; wettest and driest years based on a 79-year record, 1873 to 1952.

[3] Trace.
[4] In 1932.
[5] In 1941.
[6] In 1947.
[7] In 1884.
[8] In 1947.
[9] In 1941.
[10] In 1877.
[11] In 1884.

Complete frost data are not available within the area, but frost and freezing conditions recorded in stations nearby are representative. Practically none of the crops grown in the area are especially harmed by freezing temperatures. During the frost season, daytime temperatures frequently rise more than 20 degrees above freezing before noon. Table 2 gives frost data for Los Banos (in Merced County), Coalinga and Fresno (Fresno County), and Hanford (Kings County) weather stations. These are located northwest, east, southeast, and south of the area, respectively.

TABLE 2.—*Dates of killing frosts and average length of growing season at four weather stations near the Mendota Area, Calif.*

Weather station	Years of record	Last killing frost in spring		First killing frost in fall		Average length of growing season [1]
		Average date	Latest date recorded	Average date	Earliest date recorded	
	Number					*Days*
Los Banos	29	Feb. 26	Apr. 16	Nov. 22	Oct. 20	269
Coalinga	17	Mar. 15	May 8	Nov. 25	Oct. 31	255
Fresno	53	Feb. 11	Apr. 13	Nov. 27	Oct. 19	289
Hanford	51	Mar. 3	May 26	Nov. 14	Oct. 11	256

[1] Growing season is number of days from last killing frost in spring to first killing frost in fall.

VEGETATION

The trees in the area are mainly willows and cottonwoods that grow along the banks of the San Joaquin River, but a few shade or fruit trees have been planted around farmsteads and along roadways. West of the San Joaquin River, no trees native [6] to the region have been known to exist during recent geologic time.

Old residents remember when the basin area was covered with a dense growth of tules and tule grasses. The grasses were cut and stacked during the dry season as feed for range cattle. Today, only a scattering of tules, tule grasses, and Bermudagrass (*Cynodon dactylon*) remains in uncultivated areas. Where alkali [7] is present in the basin area, the cover is largely saltgrass (*Distichlis spicata*), and alkali bunchgrass or alkali sacaton (*Sporobolus airoides*.)

On the outer edges of the alluvial fans, where the salt content is variable but generally high, saltbush (*Atriplex* sp.) and other alkali-tolerant plants are dominant. The higher parts of the fans have little or no salt concentration and support a fair cover of annual

[6] The term "native," as applied to vegetation in various places in this report, is used in a broad sense to cover plants growing under natural conditions. In this area a number of such plants have been introduced and therefore are not, strictly speaking, native.

[7] The term alkali is used in this report in its local popular agricultural sense and therefore includes saline salts of neutral chemical reaction, such as the chlorides and the sulfates of sodium, as well as carbonates or true alkalies. In this area, saline salts (white alkali) occur in amounts considered injurious. The more toxic and very harmful carbonates (black alkali) are practically absent.

grasses and other herbaceous plants during years of favorable rainfall. The most abundant of these plants are foxtail chess (*Bromus rubens*), alfileria (*Erodium cicutarium* and *E. moschatum*), commonly termed filaree, common peppergrass (*Lepidium nitidum*), plantain (*Plantago erecta*), and burclover (*Medicago hispida*). Overwash areas near the foothills are generally covered with a fairly dense growth of brush and annually produce a beautiful and varied display of wild flowers, the dominant one being a reddish-purple flower popularly known as Indian paintbrush (*Castilleja* sp.).

The terraces and lower foothills within the area are treeless and support only a scant cover of annual grasses, herbs, and brush. In the upland section, foxtail chess, foxtail fescue (*Festuca megalura*), alfileria, and California sagebrush (*Artemisia californica*) are among the more abundant plants. Because the grasses are grazed close to the ground by sheep, many areas are practically barren of vegetation most of the year.

ORGANIZATION AND POPULATION

Authentic or definite information on early settlement of the arid west side of the San Joaquin Valley is very limited for periods before 1840. The available records indicate that only two of the many Indian tribes that roamed the plains of the valley before the arrival of white settlers ever went west of Tulare Lake. The Tache tribe hunted in Pleasant Valley south of the Mendota Area, and the Tulamni tribe lived on the west shores of Buena Vista Lake, but most of the Indians remained on the east side of the valley trough where there was adequate water and plentiful supplies of fish and game (*11*). Few tribes ever ventured west of the San Joaquin River except on occasional hunting trips. The Indians did no farming but relied entirely on the bounty of the valley.

Between 1840 and 1850 the earliest white residents were mainly nomadic sheepherders and a few cattlemen. They were not permanent settlers, and their number fluctuated according to the quantity of grass in the area. The quantity of grass was in turn dependent upon changes in seasonal rainfall. In the early 1850's a few gold miners passed through this part of the valley, and some remained to engage in limited truck farming. During the sixties and seventies, most of the land on the west side was homesteaded in 160-acre plots or purchased outright by large land companies. The homesteaders left the area as soon as they had completed government requirements for final ownership or "proved-up" on their land. They left because it was impossible to make a living on small acreages without irrigation. Because small landowners were able to survive only along the river where water for irrigation was available, there were practically no permanent residents on the broad sloping fans in the western part of the area for a long time. Later, as canals were extended to cover the higher fans, a few large-scale ranchers moved westward. In unirrigated districts of the area, the permanent population averaged less than one person for each square mile.

Heinrich Alfred Kreiser, better known as Henry Miller of the historic Miller-Lux partnership, and one of the most interesting personalities ever to settle in the San Joaquin Valley, bought the San Jon de Santa Rita Ranch several miles north of this area in 1857. During the next quarter of a century, the Miller-Lux partnership

acquired lands extending the length and breadth of the valley. Miller was primarily interested in owning land and raising cattle, but, through his many deals with other landowners and financiers, he was responsible in one way or another for the building of a railroad, a canal system, and many roads on the west side of the valley. Most of the Miller-Lux holdings have been sold, but this interesting partnership still lives on in the minds of many of the old settlers of the region.

The total population of the Mendota Area cannot be exactly determined from census reports because it is a geographic rather than a political area. Township 1 of Fresno County very closely approximates the Mendota Area, however, and population figures are given for the township. In 1910, there were 1,388 inhabitants in Township 1. In 1950, the population was 15,228, or nearly 11 times greater, and of this total 12,259 was rural farm. There was an increase of 10,263 in population between 1930 and 1950, most of which can be attributed to the enlarged agricultural activity in the area. The population of Fresno County as a whole was 276,515 in 1950 as compared with 75,657 in 1910. Between 1930 and 1950, the population increase for the whole county was 132,136.

There is a large migrant-labor population residing in camps throughout the area in the fall and early summer during the cotton- and flax-harvest season. Most of the migrant labor lives in this area 5 to 6 months of the year.

Only three small towns are located in the Mendota Area, all near the eastern border of the survey. Firebaugh, the largest of the three, had a population of 821 in the 1950 census. The town was established during the late 1880's after the Southern Pacific Railway built a west-side branch line from Fresno (in Fresno County) to Tracy (in San Joaquin County). The town was named for Andrew Firebaugh who operated a ferry across the San Joaquin River in 1854 at a place near the townsite (*16*).

Mendota, about 8 miles south of Firebaugh, was also established when the railroad was built. An added impetus was given to this settlement when the Mendota pump lifts were constructed for the San Joaquin and Kings River Canal. In 1950, the estimated population of Mendota was 1,516.

Tranquillity is situated in the southeast corner of the area near Fresno Slough. This community maintains its own irrigation and drainage system, but like its neighbor, San Joaquin (in San Joaquin County), is relatively small. San Joaquin, a small town several miles farther south along the railroad and outside of the Mendota Area, was incorporated on February 9, 1921, and in 1950 it had 632 inhabitants. Both Tranquillity and San Joaquin are sustained by farming enterprises.

CULTURAL DEVELOPMENT

All of the communities have adequate elementary schools with a rural school-bus system for the transportation of children. Branches of a county library and both Catholic and Protestant churches are maintained in each of the towns in the area.

Fishing and hunting provide the major activities for the sportsman. Ducks and pheasant are plentiful in the basin areas, and many deer range the back country of the Coast Range. Shooting privileges sold by ranchers in the hill country, or by private and commercial

gun clubs in the valley, are of considerable commercial importance. For additional recreation the Yosemite, Sequoia, and Kings Canyon National Parks are not far distant in the Sierra Nevada to the east.

INDUSTRIES, TRANSPORTATION, AND MARKETS

Several large cotton gins near Firebaugh and Mendota provide the major industrial activity of the area. Many people are employed most of the year at a packing shed in Firebaugh where vegetables are prepared for shipment. The hundreds of tractors in the fields require occasional repair, and several large welding and machine shops are kept busy the year around. At the time of survey, two experimental oil wells were being drilled in the southeastern section of the area south of Panoche Creek. In addition to these activities, there are stores, garages, banks, and warehouses, which make each community complete in itself.

Transportation by rail or motor truck is available from the main shipping points in the area to both the coast and the inland markets. The main San Joaquin Valley line of the Southern Pacific Railroad is located midway between the valley trough and the eastern edge of the valley. At Fresno, a branch line crosses to the west side of the valley, runs through Kerman in Fresno County, Mendota, Firebaugh, South Dos Palos and Los Banos in Merced County, and Newman in Stanislaus County, and joins the main line again at Tracy. Tranquillity is connected to the valley-branch line by a spur which turns off about 7 miles east of Mendota and runs south through San Joaquin. A main highway parallels the railroad and augments the facilities for transportation of livestock, truck crops, and field crops to market. San Francisco is the major outlet for the products of the west side of the San Joaquin Valley, but Fresno receives much of the flax crop.

AGRICULTURE

In the early 1850's, a few of the gold seekers settled near the San Joaquin River in the area and soon discovered that supplying truck crops to the miners was more profitable than mining. Small farms developed slowly on the west side of the valley, however, mainly because the gold-mining centers were some distance to the north and east. The communities of Fresno, Stockton, and Sacramento were already well established and able to supply most of the needs of the early miners.

During the next decade, several large operators tried dry-farmed wheat. At first yields were high during years of favorable rainfall, but they declined rapidly. Wheat growers suffered losses and finally adopted the practice of fallowing. After several bad years, they changed to barley, a crop that seemed better suited to the prevailing climate. Nevertheless, dry-farming with less than 10 inches of annual rainfall was a difficult and risky enterprise. San Francisco was the principal market for the crops, but transportation costs were high. The San Joaquin River was navigable during the spring, but grain was seldom harvested and threshed in time for shipment on the river, and storage costs until the following spring were high. Consequently, some of the planters went into the cattle business.

During the early seventies, the beginning of an extensive system of irrigation canals and the building of the Southern Pacific Railroad through the valley occurred at almost the same time. This diverted

some attention from the main industries of cattle and sheep raising and encouraged irrigated grain farming. As irrigation canals were extended and shipping facilities were improved, more land was cultivated. Wheat and barley were the important crops, but a considerable acreage was planted to alfalfa and general truck crops. Several attempts were made to establish vineyards and orchards, but the quality of the fruit was inferior to that grown near Fresno on the east side of the valley. There was a slow, steady expansion of irrigated agriculture, but no significant new crops were added until after 1920. Following World War I, the new agricultural communities of Tranquillity and San Joaquin began to develop. This new irrigated area was planted mainly to barley, other small grains, and alfalfa. A small acreage was used for general truck crops.

Cattlemen have now almost disappeared from the area. They have migrated to the north and east where the rainfall is higher and the pasture is more dependable. The sheepmen have remained, and sheep raising is still one of the important enterprises. Sheep find sufficient pasture on the western plains and foothills for several months in the spring and early summer and are later moved to other pasture areas in the valley or in the mountains. Some sheep are fed crops or allowed to supplement their pasture feed by grazing stubble fields.

CROPS

Several major changes in the agriculture of the Mendota Area have taken place rather recently (table 3). One important change was a great increase in cultivation of cotton since 1945. Earlier plantings of cotton in California were made mainly in the Imperial Valley, but the trend in recent years has been toward a concentration of plantings in the San Joaquin Valley. More than 97 percent of the yearly California cotton plantings are in this valley.

TABLE 3.—*Acreage of principal crops and number of bearing fruit and nut trees and grapevines in Fresno County, Calif., for stated years*

Crop	1919	1929	1939	1949
	Acres	*Acres*	*Acres*	*Acres*
Wheat, threshed	27, 476	25, 132	21, 780	62, 641
Barley, threshed	36, 252	35, 138	60, 938	143, 062
Grain sorghum	5, 255	1, 558	3, 167	1, 829
Flaxseed, threshed	(1)	(1)	30, 891	19, 449
Rice	60	1, 980	2, 848	14, 495
Alfalfa	64, 056	51, 897	46, 079	68, 744
Small grains cut for hay	23, 619	23, 973	17, 007	11, 453
Sugar beets for sugar	(1)	(1)	1, 326	1, 777
Cotton	5, 551	51, 457	70, 224	226, 592
Vegetables	635	2, 227	4, 994	15, 436
	Number	*Number*	*Number*	*Number*
Peach trees	2, 515, 288	1, 099, 549	770, 365	846, 225
Apple trees	77, 364	13, 492	12, 354	12, 753
Plum and prune trees	120, 963	318, 217	148, 954	327, 455
Fig trees	(1)	1, 089, 764	856, 925	728, 293
Apricot trees	176, 838	240, 536	225, 695	77, 665
Orange trees	150, 577	205, 868	230, 415	286, 269
Lemon trees	18, 023	17, 837	16, 107	15, 151
Walnut trees	3, 837	12, 628	13, 725	30, 710
Almond trees	(1)	10, 323	13, 487	71, 962
Grapevines	59, 868, 677	84, 501, 144	74, 788, 483	78, 732, 391

[1] Not reported.

Flax was introduced in the San Joaquin Valley in 1935. By 1939 there were 30,891 acres of flax harvested in Fresno County. This was increased to 43,628 acres, nearly one quarter of the total flax planted in California, in 1944. By 1949, however, the acreage planted to flax had declined to 19,449 acres, or about one-eighth of the State total.

Rice is well adapted to those basin lands having a dense clay subsoil, and each year an increased acreage has been planted. Poorly drained areas formerly useful only as duckponds for private or commercial shooting are now producing rice.

In the Firebaugh and Mendota districts, large areas have been planted to asparagus, winter peas, carrots, spinach, and melons. The development and expansion of new crops has required additional labor and large expenditures for equipment, deep wells, warehouses, cotton gins, and similar improvements.

Table 3 shows the trend of agriculture for the county, but this should not be considered as entirely representative of the Mendota Area, because there is a marked contrast between the diversified agriculture of the larger part of Fresno County on the east side of the valley and that on the west. In the east-side area, a wide variety of field, truck, and orchard crops are grown. The principal crops in the Mendota Area are cotton, small grains, flax, and hay.

Although some of the soils in the Mendota Area are inherently capable of supporting a varied intensive agriculture like that of the east side of the valley, the expense of irrigation water and equipment has encouraged a trend toward large farms. Alkali accumulation in some of the soils would also prove harmful to deep-rooted or orchard crops.

The following is a brief description of the more important crops grown in the Mendota Area.

SMALL GRAINS

Barley is one of the major crops in Fresno County. Irrigated barley will yield about 20 sacks to the acre, but dry-farmed barley yields less than 10 sacks, even during favorable years. Wheat, oats, and other cereals are also planted, but produce lower yields. The same general cultural practices as those used by flax growers are effective in obtaining the better yields of barley. Rust and smut, the most troublesome diseases, are controlled by treating the seed with copper carbonate or an organic mercury dust, and by using rust-resistant varieties.

GRAIN SORGHUM

Grain sorghum is usually grown in rotation with cotton. Double Dwarf milo is the only variety planted, and it yields very well. Although adapted to a wide variety of soil conditions, it is not so tolerant of alkali as cotton. Seed is treated with copper carbonate or an organic mercury dust to control smut.

RICE

Rice is becoming an increasingly important crop in the basin area. It is especially adapted to the soils of heavy (or fine) texture that have a dense, impervious subsoil, as it requires flooding until it reaches maturity. Rice is fairly tolerant of alkali, but after 2 years of flooding

the soluble salts in the upper root zone should be washed out. A good quality of rice is consistently obtained, and the average yield is about 27 hundred-pound sacks to the acre. All of the crop is shipped out of the area to inland and coastal markets.

ALFALFA

Alfalfa is grown throughout the basin area wherever soil conditions permit. If alfalfa is carefully handled and fertilized, a yield of 6 tons to the acre can be expected. The stand will produce well for 5 or 6 years after seeding. Some growers specialize in young high-quality hay, which requires that they cut the crop before it blossoms. Frequent early cutting reduces the life of the crop, but this is compensated for by a higher price per ton. It is more profitable to reseed frequently than to maintain a long-time stand at the expense of quality. Most of the alfalfa is used locally or in neighboring areas as feed for dairy cattle. Bacterial wilt sometimes becomes troublesome, but no control other than the seeding of resistant varieties is employed. During some years the alfalfa caterpillar is a serious pest. It is effectively controlled by cutting the crop when the larvae are most numerous, thus destroying the larvae and newly laid eggs. One or two immature cuttings usually eliminate the caterpillar for the current year.

COTTON

Cotton is the most extensive row crop in the area, and all of it is the Acala variety developed at the Shafter Experiment Station of the United States Department of Agriculture. This early maturing, high-yielding variety will produce fibers ranging from $1\frac{1}{16}$ to $1\frac{5}{32}$ inches in staple length. The average yield has steadily increased. Under ideal conditions several special fertilized and irrigated fields have produced from 1,200 to 1,400 pounds of lint an acre.

Cotton is planted from April 10 to May 15 and harvested from October through January. Harvest during January is frequently interrupted or prevented by rainy weather.

The crop is cultivated in rows and irrigated 3 or 4 times with 6 to 8 acre-inches of water, the amount depending upon the texture of the soil. In most places fields are preirrigated so as to wet the soils to depths of 5 or 6 feet before planting. Fallowing, green manuring, and occasional applications of barnyard manure are generally practiced by the successful farmers. Cotton does well on a variety of soils and is moderately tolerant of alkali. There are no pests in this area that seriously injure the crop, though occasionally grasshoppers, red spiders, or thrips cause some loss. The cotton is ginned in the area, and most of it trucked to San Francisco for further distribution.

FLAX

Flax is grown on the better drained parts of the broad alluvial fans where deep-well irrigation has been developed. Yields range from 20 to 35 bushels of clean flaxseed an acre; the average is about 23 bushels. At the time of survey the seed was being shipped east for oil extraction. Some of the straw is shipped south to be used in the manufacture of cigarette paper.

Flax is planted the first of November and harvested early in June. The ground is prepared and then thoroughly soaked with 8 to 12

acre-inches of water applied by the furrow method. When the soil can be worked again after irrigation, it is leveled and the flaxseed drilled. The preirrigation may have to be supplemented with a shallow irrigation by the check method in March or April if the winter rains have been unusually light. Consistently high yields are maintained by farmers who regularly fallow their lands or turn under a crop of clover. According to the flax farmers, summer fallowing seems to offset the bad effects of the high salt content in the well water used in this area. Flax mildew has caused an early dropping of the seed bolls on a limited acreage. The fields are relatively clean of weeds because most of the flax acreage is irrigated with well water and sown with clean seed.

VEGETABLES AND MELONS

Winter peas, carrots, spinach, asparagus, and other truck crops are grown principally in the Firebaugh and Mendota districts. These are profitable cash crops that mature in time to meet a high-priced market. The yields compare favorably with those obtained in other areas where vegetables are grown more extensively, but the quality is not so high. Melons, mostly cantaloups and honeydews, are also grown with fair success, but again the quality of fruit is not exceptional. The generally accepted methods of irrigation and fertilization are used.

PASTURE

Pasture in the Mendota Area is any tract that produces a stand of grass. The quality of unirrigated pasture on the broad alluvial fans and the uplands is dependent upon seasonal rainfall. Most of the irrigated pasture, consisting of both wild and tame grasses, is on the fine-textured soils of the basin and semibasin areas where alkali is the factor limiting land use. There is far more unirrigated pasture land than irrigated, and the carrying capacity varies greatly. The average carrying capacity through the year on irrigated pasture is 8 to 10 sheep per acre.

LIVESTOCK

In livestock production, the Mendota Area ranks very low as compared with the rest of Fresno County. Three dairies and a single beef-fattening yard, located in the northeastern corner of the area, account for most of the cattle.

The sheepmen have survived the disadvantages of low rainfall and sparse forage. They pasture large flocks on the alluvial plains and lower foothills. Most of the profit is derived from spring lambs and wool. Butchering is done mainly in Fresno, San Francisco, or Los Angeles.

TENURE, SIZE, AND TYPES OF FARMS

Most of the farms of the Mendota Area are of the general-crop type, producing for the most part cotton, small grains, flax, and in some places alfalfa grown in rotation. Farms on the alluvial fans in the western part of the area are necessarily larger than those in the eastern part near the San Joaquin River.

Fresno County as a whole has shown a considerable decrease in farm size since 1880, and the area of improved land has steadily in-

creased as irrigation and transportation facilities have been improved. In 1949, improved land constituted about 31 percent of all farm land in Fresno County, and about 71 percent of the improved land was irrigated.

According to the 1950 census there were 10,147 farms in Fresno County. About 10.6 percent of these were less than 10 acres in size. The largest number, 35.8 percent of the total, were 10 to 29 acres in extent. Farms of 30 to 49 acres accounted for 22.6 percent. The remaining 31 percent of the farms in Fresno County were larger than 50 acres and were distributed as follows: 50 to 69 acres, 7.9 percent; 70 to 99 acres, 7.2 percent; 100 to 139 acres, 3.8 percent; 140 to 179 acres, 2.7 percent; 180 to 219 acres, 1.1 percent; 220 to 259 acres, 0.9 percent; 260 to 499 acres, 2.7 percent; 500 to 999 acres, 1.9 percent; and farms of 1,000 acres and over, 2.8 percent.

Table 4 gives farm tenure and farm areas for stated years in Fresno County.

TABLE 4.—*Farm tenure and acreage for stated years in Fresno County, Calif.*

Year	Number of farms				Land in farms	
	Total	Operated by—			Total	Average per farm
		Owners	Tenants	Managers		
					Acres	*Acres*
1920	8, 917	7, 291	1, 338	288	1, 319, 531	148
1930	10, 334	7, 870	1, 525	939	1, 493, 477	145
1940	9, 550	7, 958	1, 419	173	1, 463, 868	153
1950	10, 147	8, 881	1, 148	118	2, 034, 916	201

SOIL SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field (*6*) and the recording of their characteristics, particularly as they affect the growth of various crops, grasses, and trees.

The soils and underlying formations are examined systematically in many locations. Test pits are dug, borings are made, and exposures such as those in road or railroad cuts are studied. Each excavation reveals a series of distinct soil layers or horizons called, collectively, the soil profile. Each horizon of the soil, as well as the parent mateial, is studied in detail; and the color, structure, porosity, consistence, texture and organic-matter content, roots, gravel, and stone are noted. The chemical reaction of the soil [8] and its lime and salts content are determined by simple tests.[9] The drainage, both internal

[8] The reaction of the soil is its degree of acidity or basicity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values, basicity; and lower values, acidity.

[9] Lime is determined by the reaction of the soil to dilute hydrochloric acid, and the total content of readily soluble salts is determined by the use of the electrolytic bridge. Phenolphthalein solution is used to detect a strong basic reaction.

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and external, and external features, such as the relief or lay of the land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, with special emphasis upon the features influencing their suitability for crop plants, grasses, and trees. On the basis of these characteristics, soils are grouped in classification units. The three principal ones are: (1) series, (2) type, and (3) phase. Areas of land, such as riverwash or rough broken land, having little or no true soil are called (4) miscellaneous land types.

The series is a group of soils having the same genetic horizons, which are similar in important characteristics and arrangement in the soil profile, and have the same type of parent material. The series consists of soils having essentially the same color, structure, and other important internal characteristics, and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given geographic names taken from places near which they were first identified. Thus Kettleman, Lost Hills, Panoche, and Merced are names of a few of the soil series in the Mendota Area *(10)*.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the class name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, or clay, is added to the series name to give the complete name of the soil type. For example, Kettleman silty clay loam and Kettleman fine sandy loam are soil types within the Kettleman series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics.

A phase [10] of a soil type is a subdivision of the type. Each phase differs from the others in some soil characteristic, other than a major profile characteristic, that may have practical significance. Differences in soil depth or drainage are sometimes shown as phases. Panoche clay loam, shallow, over Panhill soil material, is an example of a soil phase separated because of differences in soil depth.

The soil surveyor makes a map of the county or area showing the location of each soil type, phase, or miscellaneous land type, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS

In the Mendota Area, most of the soils characteristic of the arid west side of the San Joaquin Valley are represented. More than 75 percent of the soils of the area are well drained. The wide range in texture gives rise to a complex pattern of soil types. Figure 2 graphically represents two east-west cross sections of the soils in the area.

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[10] In this report and in the legend of the soil map, the word "phase" is omitted from the phase name in order to simplify the name. For example, Kettleman silty clay loam, undulating phase, is listed simply as Kettleman silty clay loam, undulating.

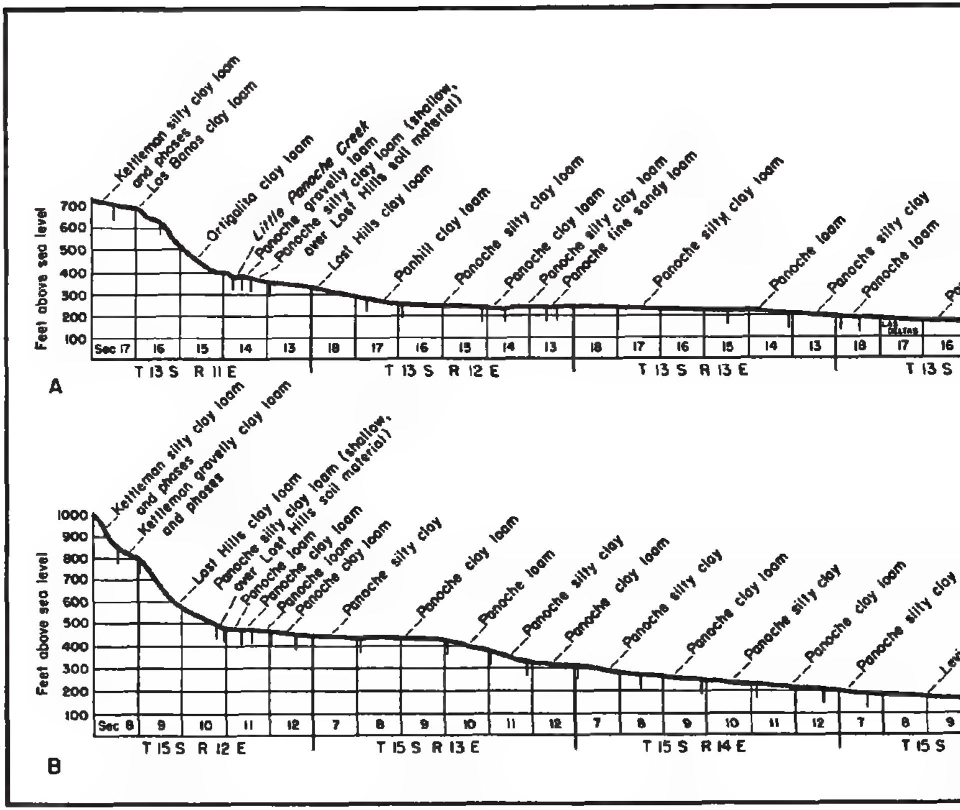


FIGURE 2.—Geographic relation of soils in the Mendota Area, Calif. *A*, West to east a
to east along Clay Avenue.

This survey was made in greater detail and on a larger scale than previous ones [11] that covered parts of the same area. The earlier surveys were of broader, or reconnaissance, character. An accumulation of data from field study and much progress in soil science, in soil classification, and in techniques of mapping since the earlier surveys have made many refinements in soil classification possible, including the division into two or more series of the soils formerly placed in a single series.

This survey establishes several new soil series, replaces or further separates a few of the soil series and types appearing in older surveys *(3, 8, 13)*, and shows areas of alkali accumulation in more detail. The more important changes in classification are discussed in the section on Soil Series, Types, and Phases.

SOILS AND THEIR RELATIONS

The soils of the area are placed in seven groups and their relationships to one another are discussed. It will be noted that these groups closely follow the natural physiographic divisions of the area and are associated with distinct differences in soil profile. These groups include soils developed from consolidated bedrock material; soils developed from old unconsolidated terrace material; soils developed from older alluvial fan material; soils of the recent alluvial fans and river flood plains; soils of the valley-basin rim; soils of the valley basin; and miscellaneous land types. The soils within each group have many profile characteristics in common and are closely related as to mode of formation and stage of profile development. On the following pages, the seven groups are briefly described and the soil series represented in each enumerated. Geologic history, method of formation, and sample profiles are given for each group in the section on Morphology and Genesis of Soils. A detailed description of each series is given in the subsection on Soil Series, Types, and Phases. Figure 3 shows the location of the physiographic groups of soils in the area. The areas of miscellaneous land types are too small and scattered to be shown on this generalized map.

SOILS DEVELOPED FROM CONSOLIDATED BEDROCK MATERIALS

Only one soil series, the Kettleman, is included in this group. Kettleman soils are representative of an extensive area of upland soils extending along the eastern edge of the Coast Range Mountains from the vicinity of Los Banos (Merced County) in the north to Maricopa (Kern County) in the south. The alluvial parent material of the lower lying soils of the Panhill, Lost Hills, Oxalis, Levis, Lethent, and the extensive Panoche series has accumulated principally through geologic erosion of the Kettleman soils and of the soft rock material underlying them.

SOILS DEVELOPED FROM OLD UNCONSOLIDATED TERRACE MATERIALS

Soils developed from old unconsolidated terrace materials are those of the Los Banos series. In the Mendota Area they are confined to approximately 3 square miles located north of Little Panoche Creek

[11] Most of the Mendota Area was covered by parts of the early San Joaquin Valley reconnaissance soil surveys and the older soil survey of the Fresno Area.

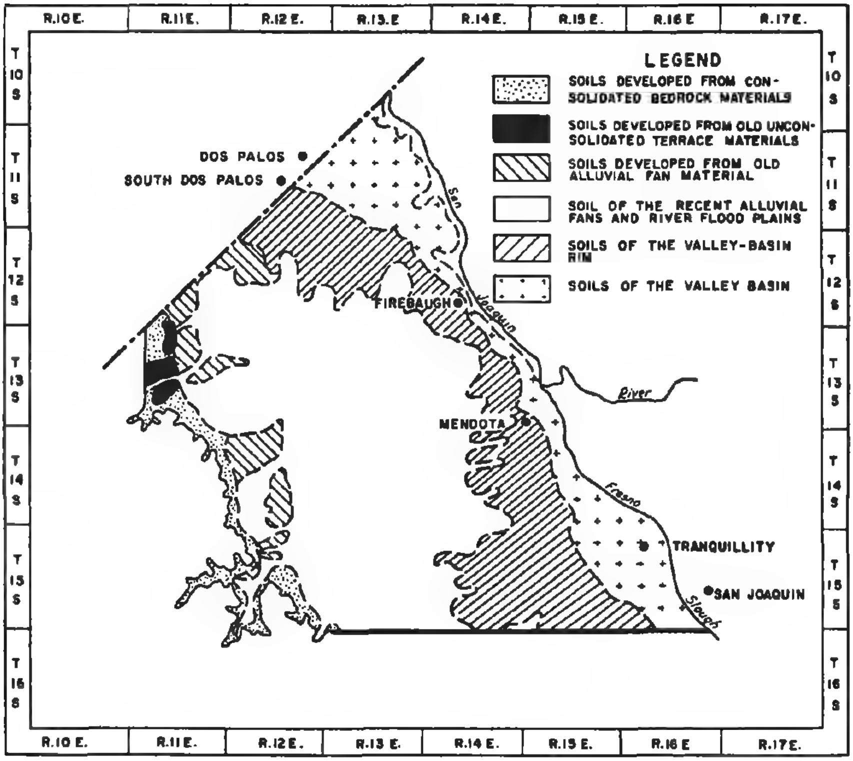


Figure 3.—Groupings of soils in the Mendota Area, Calif.

along the edge of the foothills at an elevation ranging from 300 to 700 feet. To the north in the Los Banos Area (*1*), these soils occur more extensively.

Soils of the group are characterized by a light reddish-brown, friable profile that is usually calcareous throughout. The terraces upon which these soils occur have level or gently undulating surfaces and steeply sloping sides. Erosion is slight on the smooth terrace tops but moderately severe on the steep sides. The soils are associated with the Kettleman. In some places the terrace material overlies, at a relatively shallow depth, the sandstone or shale rock giving rise to the Kettleman soils. The vegetation consists mainly of shallow-rooted annual grasses.

SOILS DEVELOPED FROM OLDER ALLUVIAL FAN MATERIALS

Soils developed from older alluvial fan materials include two soil series, the Lost Hills and Ortigalita. These are distinctly different soil series but have several important characteristics in common. Both have moderately compact subsoils and noncalcareous or intermittently calcareous surface soils, and both occur on the older, short, steep fans lying at the base of the foothills in the western part of the Mendota Area.

The Lost Hills soils, with their grayish-brown surface soils and a pronounced hummocky microrelief, are dominant on the older

alluvial fans. They have developed mainly on material outwashed from areas of Kettleman soils. The reddish-brown and hummocky soils of the Ortigalita series have developed mainly on outwash material from terrace areas of the Los Banos soils.

SOILS OF THE RECENT ALLUVIAL FANS AND RIVER FLOOD PLAINS

Soils of the recent alluvial fans and river flood plains are the Panoche, Panhill, and Columbia. The Panoche and Panhill soils occupy the broad recent or young alluvial fans in the central part of the west-side plain, and the Columbia soils occupy the recent flood plain along or near the San Joaquin River. Collectively, the soils comprise more than one-half of the total acreage of the area. Instead of erosion, there has been deposition of fresh alluvial material adjacent to Panoche and Little Panoche Creeks and the San Joaquin River.

The Panoche soils have uniform, light yellowish-brown or pale-brown, calcareous profiles in which there is a wide range of texture. The Panhill soils have some profile characteristics in common with the Panoche but some individual differences. The Panhill soils are somewhat intermediate between the Panoche and Lost Hills soils in stage of profile development and therefore have qualities similar to both. The Columbia soils are developed from recently deposited permeable alluvium along or near the San Joaquin River.

SOILS OF THE VALLEY-BASIN RIM

Four soil series, the Willows, Oxalis, Lethent, and Levis, occur on the outer edges of the alluvial fans or basin rims. Their parent material consists almost exclusively of a fine-textured, calcareous alluvium that originates to the west in the areas of softly consolidated calcareous sandstones and shales that give rise to the Kettleman soils. The soils are fine-textured and are generally characterized by moderate to strong concentrations of alkali and by variable but usually high concentrations of gypsum. With the exception of the Willows series, the soils have not been affected by a natural high water table. Surface runoff is very slow, however, and salts have accumulated because floodwaters have had a rather high salt content.

The Willows series occurs in a more nearly basinlike position and is frequently affected by a high water table for considerable periods of time. The Willows soil has been included with soils of the valley-basin rim because its parent material and content of gypsum and soluble salts are similar to those of the other soils in this group.

The Oxalis series occurs on the outer parts of alluvial fans; it is associated with soils of the Panoche series but occurs at slightly lower elevations. The soil is typically darker colored than the Panoche, and generally has higher concentrations of gypsum and soluble salts. It is also associated in places with the dark-colored Merced soil of the basins and with the Lethent soil.

Lethent soil is at about the same stage of development as the Lost Hills soils but somewhat older in development than the Oxalis. It might be included in the group of soils developed on older alluvial fan materials. In places, Lethent soil is associated with soils of the Lost Hills series, but it is at lower elevations and occurs in positions more nearly like those of other soils of the valley basin rim. The Lethent soil also contains strong concentrations of alkali.

Levis soil is intermediate in development between the recent Panoche soils and the moderately developed Lethent soil. It occupies a wide transition zone between the Panoche soils and the more strongly developed soils of the basin rims.

SOILS OF THE VALLEY BASIN

The soils of the valley basin are intimately woven into a complex soil pattern. There are four associated soil series, the Merced, Temple, Rossi, and Traver, in the valley basin. All of the soils are developed mainly from granitic sediments, originally derived from the Sierra Nevada on the east side of the valley, that have been deposited by waters of the San Joaquin River or Fresno Slough.

The Merced and Temple soils are the darker colored, fine-textured, poorly drained soils of the basins. The Traver soil occurs on low ridges above the general level of the basin soils and is of coarser texture and lighter color. The Rossi soil is fine-textured and dark-colored but of lower organic-matter content and less permeable than the Temple or Merced. The Temple soils normally are higher in organic-matter content than the Merced soils and of somewhat more permeable profile; and of the two, the Merced soils generally have a higher content of salts or alkali. The Rossi and Traver soils normally contain moderate or strong concentrations of salt, and appear to be in a more advanced stage of profile development than any of the others in the group.

This group of four soils comprises part of a large, prominent basin area that extends nearly the length of the San Joaquin Valley, and these soils also occur extensively in the adjacent Los Banos area *(1)*.

MISCELLANEOUS LAND TYPES

Miscellaneous land types are Riverwash and Rough broken land. Riverwash consists of the gravel and loose sand along the larger streams and has not yet developed as a true soil. Rough broken land consists of badly dissected upland areas that have very shallow soil and a sparse plant growth. Both types are almost useless for any agricultural purpose.

SOIL SERIES, TYPES, AND PHASES

In this section, the soil series, types, phases, and miscellaneous land types are described and their agricultural relationships are discussed. The location and distribution of the mapping units are shown on the accompanying soil map,[12] and their acreage and proportionate extent are given in table 5. Where a soil type has been subdivided, the soil of most common occurrence is generally described first.

COLUMBIA SERIES

Columbia soils are derived from alluvial deposits of mixed geologic-rock origin. A predominance of granitic rock material makes them distinctly micaceous. The alluvium has been laid down in the recent river flood-plain area in a narrow band immediately adjacent

[12] Because soil boundaries are indefinite in many places, the boundary lines on the soil map represent the approximate center of a fairly broad transition zone.

TABLE 5.—*Approximate acreage and proportionate extent of soils mapped in Mendota Area, Calif.*

Soil	Acres	Percent
Columbia fine sandy loam	2, 967	0. 8
Columbia loam	2, 262	. 6
Columbia soils, undifferentiated	815	. 2
Kettleman fine sandy loam:		
Hilly, eroded	1, 428	. 4
Steep, eroded	316	. 1
Undulating	968	. 3
Kettleman gravelly clay loam:		
Hilly, eroded	1, 037	. 3
Steep, eroded	312	. 1
Undulating	360	. 1
Kettleman silty clay loam:		
Hilly, eroded	3, 856	1. 0
Rolling, eroded	1, 233	. 3
Steep, eroded	967	. 2
Undulating	3, 376	. 9
Kettleman stony clay, very gently sloping	164	. 1
Lethent silty clay	7, 028	1. 9
Levis silty clay	23, 490	6. 2
Los Banos clay loam, steep	534	. 1
Los Banos clay loam, undulating and rolling	1, 849	. 5
Lost Hills clay loam:		
Gently sloping	716	. 2
Very gently sloping	16, 538	4. 4
Lost Hills gravelly clay loam, sloping	72	(1)
Lost Hills loam, very gently sloping	432	. 1
Merced clay (adobe)	35, 013	9. 3
Shallow, over Traver soil material	4, 739	1. 3
Shallow, over Willows soil material	660	. 2
Ortigalita clay loam:		
Gently sloping	699	. 2
Very gently sloping	1, 550	. 4
Oxalis silty clay	69, 217	18. 4
Panhill clay loam:		
Gently sloping	1, 858	. 5
Very gently sloping	5, 466	1. 5
Panhill silt loam:		
Gently sloping	802	. 2
Very gently sloping	393	. 1
Panoche clay loam	40, 609	10. 8
Shallow, over Panhill soil material	403	. 1
Panoche fine sandy loam	17, 272	4. 6
Panoche gravelly loam	1, 183	. 3
Panoche loam	26, 140	6. 9
Panoche loamy fine sand	817	. 2
Panoche silt loam, shallow, over Lost Hills soil material	1, 702	. 5
Panoche silty clay	38, 710	10. 3
Panoche silty clay loam	32, 952	8. 6
Panoche silty clay loam, shallow, over Lost Hills soil material	4, 035	1. 1
Riverwash	578	. 1
Rossi clay loam	492	. 1
Rough broken land	1, 224	. 3
Temple clay loam	3, 033	. 8
Temple silty clay	1, 349	. 4
Shallow	4, 344	1. 2
Temple silty clay loam	9, 119	2. 4
Traver fine sandy loam	209	. 1
Willows clay	1, 032	. 3
Total	376, 320	100. 0

[1] Less than 0.1 percent.

to the San Joaquin River and in an occasional armlike outward extension where the river has overflowed its banks at some time. The soil profiles are recent, undeveloped, and uniformly permeable and friable. Levees have protected the soils from recent deposition of alluvial materials. A seasonal 5- to 6-foot ground-water table occurs, and the soils are imperfectly drained. For the most part, they are free from alkali, but a relatively small area in the northeastern part of the survey is slightly affected. At present, most of these soils are cultivated. The native vegetation consisted of brush, grasses, and cottonwood trees close to the river.

The surface soil is grayish brown or light grayish brown, noncalcareous, and medium to coarse in texture. It is very friable, easily penetrated by roots and water, and moderate in its moisture-holding capacity. There is a considerable quantity of mica in both the surface soil and subsoil, and the organic-matter content throughout is low. The surface soil is nearly neutral or slightly basic in reaction and grades slowly into a similar light brownish-gray sandy subsoil. Except for a slight color change and a noticeable degree of rust-brown mottling, the subsoil is identical to the surface soil. It continues to depths of more than 6 feet. The deeper subsoil is in many places more stratified and coarser textured than the upper soil, and generally it is more highly mottled because of the high water table.

The Columbia soils are associated mainly with the dark-colored, fine-textured Temple soils occurring in the lower lying basin positions that border areas of the recent river flood plain. In the earlier reconnaissance survey of the lower San Joaquin Valley (*8*), the Columbia soils were included mainly with the Hanford.

Columbia fine sandy loam (0- to 3-percent slopes) (CA).—A narrow, nearly level band of this soil, adjacent to and roughly paralleling the course of the San Joaquin River, extends from a point north of Mendota to the northern boundary of the area.

The surface soil is a light grayish-brown or grayish-brown noncalcareous fine sandy loam that is porous and very friable. This layer, averaging about 20 inches in depth, is micaceous, and, like the entire soil profile, it is neutral or slightly basic in reaction. There is a gradual transition to a light brownish-gray noncalcareous sandy loam subsoil that is noticeably streaked with rust-brown mottling. From a depth of 40 inches downward, the sandy substratum is light brown or light brownish gray, highly mottled with iron stains, and often stratified with finer textured silt or clay loam. The stratified materials making up the soil profile are similar throughout. Several included areas have a coarser texture than is normal for Columbia fine sandy loam.

Excellent yields of cotton, field corn, alfalfa, and, in fact, of almost any crop climatically suited to the region, are consistently obtained under good management. Practically all of the soil is intensively cultivated, and the native cover of grass, brush, and cottonwood trees has almost disappeared. The water table fluctuates with the water level of the river but rarely remains closer to the surface than 48 inches for any length of time. Most of the soil is free from alkali, but a small acreage contains a slight concentration in the subsoil. The soil is adequately protected from overflow by a series of levees, and no deposition of alluvial material from floodwaters has taken place recently.

Columbia loam (0- to 3-percent slopes) (Cb).—This soil occurs along the channel of the San Joaquin River from its junction with Fresno Slough to the northern boundary of the area. Levees along the river prevent the annual flooding that took place before the soils were cultivated.

The surface soil is a grayish-brown or light grayish-brown, highly micaceous, friable, noncalcareous loam. It has a relatively low organic-matter content and is neutral or slightly basic in reaction. At an average depth of 20 inches, a light brownish-gray noncalcareous subsoil of fine sandy loam texture is usually encountered. It is micaceous, considerably streaked with rust-brown mottling, and slightly basic in reaction. Below a depth of about 40 inches, the substratum is usually a light-gray, highly micaceous fine sand, noncalcareous and loose. Rust-brown mottling is more frequent in this layer than in the one above, due to recurrent ground water. The entire profile is easily penetrated by roots and water.

Nearly all of the soil is farmed to cotton, field corn, small grains, and alfalfa. Excellent yields are obtained if crops are sufficiently irrigated and the soil is regularly treated with a dressing of barnyard manure. A few small areas that are slightly spotted with alkali give lower crop yields corresponding to the area affected and the concentration of alkali. The water table fluctuates with the water level in the river but seldom rises above a depth of 48 inches for any extended period of time. The native cover of grass, brush, and cottonwoods has largely been replaced by a mixture of weeds carried by irrigation waters from the San Joaquin River.

Columbia soils, undifferentiated (0- to 3-percent slopes) (Cc).—These soils, ranging in texture from coarse sand to loam, are subject to flooding by the San Joaquin River, and they are so complexly associated that it is impractical to differentiate them as several individual soil types.

The variable textured surface soils are grayish brown, noncalcareous highly micaceous, and often mottled with rust-brown stains. The subsoils, beginning at a depth of approximately 20 inches, consist of light brownish-gray or light-gray stratified material that is highly micaceous and considerably mottled with dark-brown rusty stains. The substratum to a depth of 72 inches or more is usually coarser textured and more highly mottled in the lower parts. Occasionally, it is stratified with silt loam or loam. The entire profile is easily penetrated by roots and moisture.

Only a small acreage of these soils is cultivated, and most of the native vegetation of grass, brush, and cottonwood trees remains undisturbed. Cotton has been grown with fair success, but much of this undifferentiated unit is subject to overflow and is not easily accessible. Furthermore, excessive amounts of water are usually required to mature a crop properly. Two areas located near Firebaugh have been partially excavated and the sand used in the roadbed of the new highway that passes by the town. Most of these soils are free of alkali. Ground water fluctuates with the water level in the San Joaquin River in much the same manner as it does in Columbia loam and fine sandy loam.

KETTLEMAN SERIES

The Kettleman soils have developed in place from underlying rather softly consolidated calcareous shale and sandstone and have weakly

developed profiles. In this area, the predominant relief is rolling to hilly. Slopes range from 10 to 40 percent, but more gently or more steeply sloping areas are not uncommon. Erosion is severe in many places, but generally the soils are only moderately eroded. They are readily moved when saturated and easily gullied by a relatively small runoff. Small quantities of soluble salts are sometimes present in the parent materials, and a few areas are slightly spotted with alkali. Slick spots at the base of steeper slopes are indicative of alkali accumulations, and such areas are generally badly eroded. The native vegetation consists mainly of short grasses and low brush, the extent and growth of which depend upon the amount and distribution of the seasonal rainfall.

The surface soil is light yellowish brown or light brownish gray, and calcareous. Roots and water readily penetrate, but the organic-matter content and moisture-holding capacity are low, especially where the surface soil is of the coarse-textured type. There is a wide range of texture. The surface soil has weak granular structure and readily crumbles to a soft mass; it usually merges with the light yellowish-brown or light-gray, highly calcareous upper subsoil at about 8 inches. When dry, the upper subsoil normally has vertical cracks and breaks into weak prisms when disturbed. A high lime content, in both segregated and disseminated form, maintains a friability that facilitates root and water penetration. There is a gradual transition to a yellowish-brown lower subsoil that is high in both gypsum and lime content.

The fine-textured members of the Kettleman series have a slightly compact silty clay loam or silty clay subsoil that retards root and water penetration, and there is an appreciable amount of colloidal staining on the surfaces of the small aggregates. The subsoil of the coarser textured Kettleman soils, instead of being compact and stained by colloid, is characterized by layers of partially decomposed calcareous sandstone. The lower subsoil of all types generally contains small angular, lime-coated fragments of parent rock and considerable quantities of small gypsum crystals. Softly consolidated parent material, mainly of brownish-gray, calcareous, fine-grained sandstones or occasionally shales, is usually encountered at 20 to 40 inches.

Kettleman soils are closely associated with and similar to the browner and less calcareous Altamont soils that occur west of the Mendota Area. The Los Banos soils, which are developed from terrace materials, are intimately associated with the Kettleman soils in places along the lower foothills.

Kettleman silty clay loam, hilly, eroded (20- to 40-percent slopes) (KG).—In the foothills along the western boundary of the area, this soil occurs extensively. It is one of the dominant soils of the uplands.

The surface soil is a light brownish-gray or light yellowish-brown, calcareous, friable silty clay loam of weak granular structure, readily crumbled, and permeated by many small roots and insect borings. Thickness varies considerably. The average is about 10 inches, but the surface soil is considerably thinner in some places, and in others it may be as much as 20 inches thick.

The upper subsoil is a light-gray or very light yellowish-brown highly calcareous silty clay loam that contains both segregated and disseminated lime. When dry, faint vertical cracks develop, and these give the subsoil a weak prismatic structure which is friable and

easily crumbled when disturbed. The lower subsoil, which extends to depths of 15 to 31 inches, is a highly calcareous very light yellowish-brown silty clay loam that contains an appreciable quantity of gypsum crystals. This layer is slightly more compact than the one above, and the small subangular blocky aggregates are coated with colloidal staining. The upper part of the parent bedrock is a soft, crumbly, highly calcareous fine-grained sandstone that generally contains a considerable quantity of gypsum crystals. This bedrock is usually yellowish brown or grayish brown. It occurs at depths of 20 to 31 inches, the average being 24 inches. The partially disintegrated parent bedrock, with which small amounts of soil material and grass roots are mixed, becomes more firmly consolidated with depth.

This soil is used for sheep pasture. In years of favorable rainfall, the short native grasses yield fair pasturage during the spring. In general, however, the average annual grazing value is low. Sheet erosion is moderate, and gullying is severe in a few places. Erosion has resulted primarily from intensive grazing by sheep.

Kettleman silty clay loam, rolling, eroded (10- to 20-percent slopes) (KH).—In major profile characteristics this soil is similar to Kettleman silty clay loam, hilly, eroded. The surface soil is a light brownish-gray or light yellowish-brown calcareous friable silty clay loam, overlying a light-gray or very light yellowish-brown friable silty clay loam subsoil containing some segregated lime and crystals of gypsum. Soft calcareous and gypsiferous fine-textured sandstone usually occurs at depths of 25 to 40 inches. The parent material is normally a few inches deeper in this soil than in the Kettleman silty clay loam, hilly, eroded. It is moderately eroded, and has deep gullies in some places. Erosion has been caused primarily by intensive pasturing of sheep. More careful stocking would do much to improve the quantity of forage and general grazing value.

Kettleman silty clay loam, undulating (6- to 10-percent slopes) (KL).—This soil differs from the other Kettleman silty clay loam soils in that it has more gently sloping relief, a deeper profile, and a somewhat finer textured subsoil. Several small bodies occur in the western part of the area and between Little Panoche and Panoche Creeks.

The light yellowish-brown or light brownish-gray surface soil is a calcareous silty clay loam. It is friable and moderately permeable to roots and water. This material, averaging 12 inches in thickness, grades into a highly calcareous and gypsiferous light-gray or light yellowish-brown, firm silty clay subsoil. This subsoil is slightly more compact than the surface soil, and the firm silty clay aggregates are coated with colloidal stains. A few roots penetrate this layer, and root holes and some well-preserved insect borings are usually present. Soft fine-grained sandstone bedrock containing a considerable quantity of segregated lime, and frequently some gypsum crystals, is generally encountered at depths of 30 to 40 inches. Soil particles are mixed with the partially decomposed upper bedrock, but lower in the profile the sandstone is more firmly consolidated.

This soil is used for grazing sheep. During seasons of favorable rainfall, the short native grasses produce fair to good pasture. Because the soil has a moderate water-holding capacity, the grasses last

longer on it than they do on the steeper or coarser textured Kettleman soils. Sheet erosion is normally slight, but an occasional deep gully cuts into the soft parent material.

Kettleman silty clay loam, steep, eroded (40- to 60-percent slopes) (KK).—This essentially nonarable soil is confined to a few small bodies in the western part of the Mendota Area. Although it is steeper, shallower, and more eroded than Kettleman silty clay loam, hilly, eroded, its profile characteristics are essentially the same.

The surface soil to an average depth of about 6 inches is a light brownish-gray or light yellowish-brown calcareous silty clay loam that is friable and moderately permeable to roots and water. The highly calcareous subsoil varies in depth from 4 to 18 inches. It is usually a light gray, a very light yellowish brown, or a light brownish gray, and contains appreciable quantities of gypsum crystals. The subsoil is slightly more compact and firm than the layer above. The silty clay loam aggregates are coated with colloidal stains. The depth to bedrock is extremely variable but generally less than 24 inches. The bedrock is a soft, fine-grained, calcareous and gypsiferous sandstone, partially disintegrated in the upper part but more firmly consolidated below.

The topography is generally too steep for sheep pasturing, and even during years of favorable rainfall there is only a scant cover of native grass. Sheet erosion is moderate to severe. Frequent gullies have cut down to consolidated bedrock. Grazing is limited by the scant vegetation and steep slopes.

Kettleman fine sandy loam, hilly, eroded (20- to 40-percent slopes) (KA).—This soil occurs in several bodies adjacent to Panoche Creek in the southwestern corner of the area. In a few places, slopes of 10 to 20 percent have been included. Sheet erosion is moderate, and there is frequent deep gullying in the swales.

The surface soil is a light-brown or pale-brown calcareous fine sandy loam that is very friable. This material is underlain at depths of 7 to 12 inches by a light brownish-gray or light yellowish-brown fine sandy loam subsoil containing considerable quantities of grit and coarse material. There are slight tendencies toward vertical cracking and some compaction of the soil material in this layer, but root and water penetration are not retarded. Lower in the profile, at an average depth of about 28 inches, there is a partially decomposed layer of parent sandstone material that contains numerous lime seams and appreciable amounts of dark-colored grit. This light-gray or very light yellowish-brown bedrock becomes more firmly consolidated at depths below 36 inches; it is only slightly calcareous.

The native vegetation consists mainly of short range grasses and scattered low shrubs that produce fair forage for sheep during spring seasons of favorable rainfall. The grasses are of good quality, but due to the low available water-holding capacity, they dry up earlier than the grasses on fine-textured soils, which have a higher available water-holding capacity. In general, the average grazing value on an annual basis is poor.

Kettleman fine sandy loam, undulating (3- to 10- percent slopes) (KC).—A deeper and less eroded profile and a less calcareous surface soil differentiate this soil from other Kettleman fine sandy loam soils. Most of it occurs as a single body at the base of the foothills on the

south side of Panoche Creek. An appreciable quantity of small rounded gravel from quartzite and sedimentary rocks is scattered on the surface and throughout the upper layers of the soil profile. There is not enough gravel, however, to classify this soil as a gravelly phase.

To an average depth of 10 inches, the surface soil is a very light yellowish-brown, calcareous, very friable, fine sandy loam. This is underlain at depths of 6 to 15 inches by light yellowish-brown, highly calcareous material that is slightly coarser textured than the surface soil. This layer is slightly more compact, but there are no definite structural units, and root and water penetration are not retarded. A soft, calcareous sandstone bedrock is encountered at depths of 30 to 50 inches, the average depth being about 36 inches. The upper part of the bedrock is usually partially disintegrated and mixed with soil material. Numerous lime seams are embedded in the sandstone, and an appreciable quantity of dark-colored grit is mixed with the light-brown consolidated grains of fine sand.

The vegetation consists of short range grasses and low scattered shrubs that provide pasture for sheep. The quality of this forage depends upon seasonal rainfall, and during favorable years, fair pasture is produced. Sheet erosion is slight; only occasional gullies occur in the swales between low rounded ridges.

Kettleman fine sandy loam, steep, eroded (40- to 60-percent slopes) (Kb).—Steeper relief and a shallower and more severely eroded profile are the principal features distinguishing this soil from other Kettleman fine sandy loam soils. Representative areas of this soil are located along the banks of Panoche Creek in the southwestern corner of the area.

The light brownish-gray or light yellowish-brown surface soil is a calcareous fine sandy loam ranging from 2 to 10 inches in thickness but averaging about 5 inches. It is very friable and contains many roots. The light brownish-gray or light yellowish-brown subsoil is calcareous and somewhat coarser textured than the surface soil. Its depth varies but usually does not exceed 20 inches. The underlying partly decomposed calcareous grayish-brown sandstone material has numerous lime seams throughout and contains considerable quantities of dark-colored grit.

The natural vegetative cover of short grasses and scattered shrubs is used to pasture sheep. The quality and amount of forage depend upon the seasonal rainfall, but even during favorable years the vegetation is scant on this eroded steep soil. Both sheet and gully erosion are moderate to severe.

Kettleman gravelly clay loam, hilly, eroded (20- to 40-percent slopes) (Kd).—Several relatively large bodies of this gravelly soil occur in the lower foothills along the western boundary of the area. In places some slopes of 10 to 20 percent are included.

The surface soil is a yellowish-brown or light brownish-gray calcareous gravelly clay loam. The well-rounded gravel is mostly quartzite mixed with occasional igneous rocks. The friable surface soil, 4 to 16 inches thick, contains a small amount of segregated lime. The subsoil is a very light-brown or very light grayish-brown firm gravelly clay loam, faintly stained with mineral colloids. Grass roots are not so numerous in this layer as they are in the surface soil. The gravel is usually coated with lime, and thin seams of segregated lime permeate the soil mass.

Bedrock is usually encountered at depths of 12 to 36 inches, the average being less than 20. This rock is largely a conglomerate of well-rounded gravel embedded in a moderately soft shale, the very crumbly, highly calcareous upper part of which is intermixed with soil material. The bedrock becomes more massive or firmly consolidated at depths of 36 or more inches.

This soil is used for sheep pasture, but the amount and quality of the natural grass cover are dependent upon seasonal rainfall. Sheet erosion is moderate, and there is a tendency toward severe gullying on the steeper slopes.

Kettleman gravelly clay loam, undulating (3- to 6-percent slopes) (Kf).—A greater average depth and more gentle relief differentiate this soil from Kettleman gravelly clay loam, hilly, eroded. The soil occurs along the lower foothills south of Little Panoche Creek.

The surface soil to an average depth of 12 inches is a friable, yellowish-brown, calcareous gravelly clay loam. The calcareous subsoil, very light brown or light brownish gray, contains firm clay loam aggregates stained with mineral colloids. It also contains numerous well-rounded pieces of gravel—stones variable in size but usually small, that are coated with lime. Bedrock, consisting of conglomerate, is generally encountered at an average depth of about 30 inches. The rounded gravel is only weakly embedded in the upper part of the parent material, but it becomes more firmly cemented at lower depths.

This soil is used for sheep pasture, and during years of favorable rainfall the native grasses afford fair grazing. Sheet erosion is only slight, but there is occasional shallow gullying.

Kettleman gravelly clay loam, steep, eroded (40- to 50-percent slopes) (Ke).—In profile characteristics this soil is similar to Kettleman gravelly clay loam, hilly, eroded phase, but the depth to bedrock is more variable and usually shallower. Only two bodies occur in the area, one located in the extreme northwestern corner, and the other approximately 6 miles south along the north banks of a tributary of Little Panoche Creek.

The surface soil, 4 to 14 inches thick, is a yellowish-brown or light brownish-gray, friable, calcareous gravelly clay loam that contains much hard well-rounded gravel. The very light grayish-brown or very light-brown subsoil is a calcareous gravelly clay loam slightly more compact than the layer above. It contains some segregated lime, and the rounded gravel is coated with lime. There is a slight colloidal staining of the firm clay loam aggregates. A conglomerate bedrock is encountered at an average depth of about 18 inches, but it may be very near the surface or as much as 30 inches below. The upper part of the bedrock is soft and crumbly, but the lower part is more firmly consolidated.

This soil is used for sheep pasture, but only in years of favorable rainfall is there more than a poor stand of short grasses. The soil is moderately to severely eroded; frequent gullies have cut down to bedrock.

Kettleman stony clay, very gently sloping (0- to 3-percent slopes) (Km).—This soil is very similar to Kettleman silty clay loam, undulating, except for the stoniness and finer texture of the surface soil. All of it is confined to one body in the extreme northwestern corner of the area. Sheet erosion is very slight, and there has been no gullying.

The surface soil is a yellowish-brown or brownish-gray mildly calcareous stony clay that is friable and easily penetrated by roots and water. The well-rounded stones occur only at the surface or in the surface soil and are less than 6 inches in diameter. They are composed of hard quartzite material or of a highly metamorphosed sandstone and shale with which there are occasionally some quartz and igneous rocks.

The slightly more compact subsoil, occurring at depths of 8 to 20 inches, is a light brownish-gray or light yellowish-brown calcareous clay. There is a considerable amount of colloidal staining on the faces of the small irregularly shaped aggregates, which are firm but readily crush under pressure. Lime, in both disseminated and segregated form, occurs with small quantities of crystalline gypsum, particularly in the lower subsoil. A soft shale bedrock is encountered at depths of 30 to 48 inches, the average depth being approximately 36 inches. The shale bedrock is mildly calcareous and partially disintegrated in the upper part, but it becomes more firmly consolidated at lower depths.

The vegetation of short range grasses is pastured to sheep. During years of favorable rainfall, there is a fairly good stand of grass; and, if sheep are kept off until a firm sod develops, a good pasture can be maintained until late in spring.

LETHENT SERIES

The Lethent soil is developed on old alluvial material derived mainly from fine-grained sandstones and shales that are inherently high in lime and gypsum. It occupies the basin rims on the outer and lower fringes of the broad alluvial fans, where surface drainage is slower than it is in some higher parts of the fans. The Lethent soil has probably reached a considerably older stage in development than have the recent Panhill, Levis, and Panoche soils. It is generally high in alkali and, for the most part, supports only a cover of salt-tolerant plants and shrubs. The shrubs are usually a California variety of alkali-tolerant *Atriplex*. Erosion and deposition are negligible on the Lethent soil at present.

The Lethent soil in this area is closely associated with the Lost Hills, Panoche, and Oxalis. It differs from the Lost Hills soils mainly in its lower topographic position on the outer fringes of the fans, where surface drainage is usually very slow, and in its high content of soluble salt. The Panoche soils on the well-drained higher parts of the fans have recent, or less well developed, profiles and a low or negligible salt content. The Oxalis soil is a darker colored fairly recent soil formed in basin-rim areas that are nearer than the Lethent to the main valley trough. The reconnaissance surveys of the Middle and Lower San Joaquin Valley (*3*, *8*) included part of the Lethent soils with the Capay and part with the Panoche series.

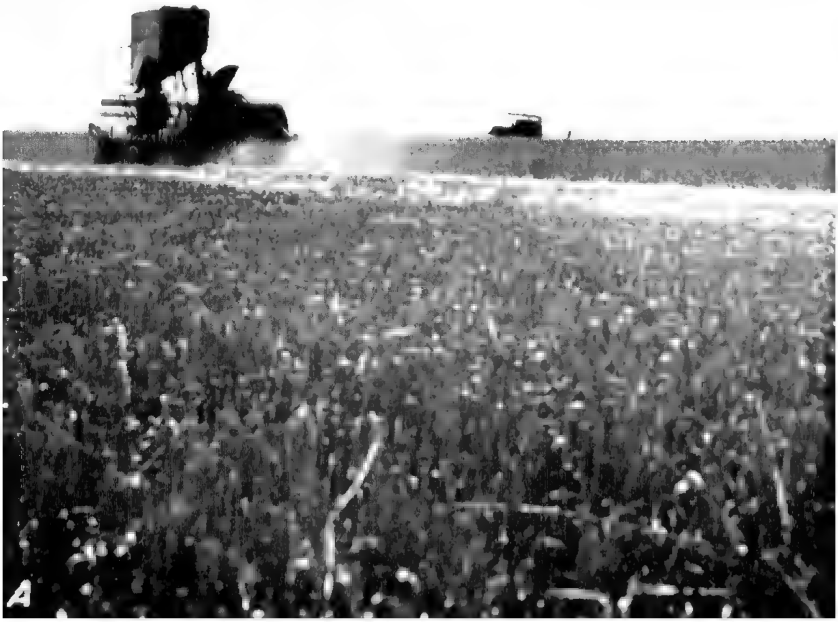
Lethent silty clay (0- to 1-percent slopes) (LA).—One large area of this nearly level soil is located north and east of Oro Loma, and another body is just north of Mendota. Surface drainage is very slow, and no appreciable erosion or deposition has taken place in recent years.

The surface soil is friable, grayish-brown, intermittently calcareous silty clay. The upper subsoil, beginning at an average depth of 8 inches, is light-brown or pale-brown silty clay. It contains a consider-

A, Lethent silty clay strongly affected by alkali; shrub vegetation is Allenrolfea. Where sufficient water is available and alkali concentration not too strong, the cultivation of rice has proved effective in reclamation of this soil.
B, Rice on Oxalis silty clay; water is supplied by canal from the San Joaquin River.

A, Alluvial fan and interfan slopes; Panhill soils in foreground, Kettleman soils on hills in background. Noncultivated areas are used mainly for sheep grazing.

B, Electrically driven turbine-type deep-well pump supplying water for irrigation of Panoche soils.



A, Combine harvesting irrigated wheat on Panoche silty clay loam.
B, Panoche silty clay loam prepared and planted to cotton.

A, Seed onions on Panoche loam.
B, Alfalfa on Temple silty clay near Dos Palos.

able quantity of segregated lime and gypsum. There is a well-defined prismatic structure in this layer when it is dry, and the firm aggregates are stained with colloids. Root and water penetration is aided by a series of vertical cracks, but the soil swells and becomes very sticky when it is wet. At depths below 30 inches, the light yellowish-brown or pale-brown lower subsoil is often coarser textured than the surface soil and generally more friable. No definite structural units are developed in this layer, but there is a noticeable amount of colloidal staining or mottling and a concentration of gypsum, segregated lime, and soluble salts.

The underlying substratum, usually encountered at an average depth of 50 inches, is a light yellowish-brown calcareous sandy clay loam material, plastic when wet and friable when moist. In many places, the substratum is stratified with layers of very fine sand or coarser material, but it is uniformly calcareous and may contain some crystalline gypsum.

The native vegetation is composed mostly of saltgrass and other salt-tolerant plants. All of the soil is affected with variable, but generally excessive, concentrations of salts (pl. 1, *A*). In favorable areas, rice may be grown with some success, but profitable cultivation of other shallow-rooted crops is questionable. The soil is best used for pasture.

LEVIS SERIES

Levis soil is composed mainly of heavy- (fine) textured sediments derived from areas of sandstone and shale rock that are high in content of lime and gypsum. It is probably a little older than the soils on the recent fans. It occupies the outer part of the fans adjacent to the basin areas. Slopes average 1 percent or less, and the surface microrelief is slightly hummocky. As a result of its high content of salts, the soil is subject to heaving, and this action has been the principal factor in the formation of the low hummocks. Erosion or deposition is negligible on this soil at present. The low annual rainfall is readily absorbed, and practically no surface runoff occurs. The scant native vegetation consists entirely of alkali-tolerant weeds and low shrubs.

The Levis soil is characterized by a brownish-gray or yellowish-brown intermittently calcareous surface soil that is fine textured and consistently high in alkali accumulation. There is a gradual change to darker brown in the upper subsoil and a faint suggestion of vertical cracking. Weak prismatic aggregates are evident when the dry soil is disturbed. High concentrations of lime, gypsum, and salts are usually present. The lower subsoil is light yellowish brown and usually contains higher concentrations of segregated lime, gypsum, and soluble salts.

Levis soil occupies a wide transitional zone between the Panoche soils, which are located on the outer edge of Panoche Creek fan, and the dark-colored and more strongly developed soils of the basin or the valley trough. They are intermediate between the recent Panoche soils and the moderately developed Lethent soil. In the earlier reconnaissance survey of the Middle San Joaquin Valley (*3*), the Levis soil was included with those Panoche soils having a high salt accumulation.

Levis silty clay (0- to 1-percent slopes) (Lb).—Large bodies of this soil are located along the outer edge of the Panoche Creek alluvial fan

south of Mendota. The microrelief is often slightly hummocky, and the relief is nearly level. Erosion is not a problem, but surface and internal drainage are very slow.

The surface soil, averaging about 6 inches in depth, is a brownish-gray or yellowish-brown intermittently calcareous silty clay. It is friable and porous and its high concentration of salts gives rise to a loose, flocculated or fluffy, condition when the soil is thoroughly dry in summer. Only alkali-tolerant plants can exist.

A brown, firm silty clay upper subsoil extends to an average depth of about 14 inches. When dry, a definite system of vertical cracks give a weak but distinct prismatic structure. The deeper subsoil, to a depth of about 32 or more inches, contains an extremely high concentration of salts that flocculates the soil into a friable crumbly mass. Below this and continuing to depths in excess of 72 inches is a light yellowish-brown highly calcareous and gypsiferous clay loam, affected by moderate quantities of soluble salts. It is friable and porous, but roots and moisture rarely reach this deep in the profile.

A small acreage of this soil is cultivated at the present time; and, considering its high alkali content, it is doubtful that it ever can be farmed successfully. At best, it affords a scant sheep pasture of native alkali-tolerant weeds and low shrubs. The soil readily absorbs rain water and becomes saturated. Because it slowly gives up its moisture through evaporation, it remains wet until late in spring.

LOS BANOS SERIES

Los Banos soils are developed on terrace material derived mainly from sedimentary rock. Former inland lakes or streams have deposited the parent material on bedrock at elevations of 300 to 1,000 feet. In this report, the material is referred to as a terrace deposit mainly because it occupies a relatively flat terrain, the steeply sloping sides of which create a resemblance to benches or terraces. The terrace material has been laid down very unevenly or it has been eroded. In places, it is so thin that the original underlying bedrock is exposed.

In this area, Los Banos soils are not extensive. The terraces on which they occur are confined to a narrow zone along the foothills north of Little Panoche Creek. Larger and more extensive terraces, however, lie west and north of the area. Erosion is only slight on Los Banos soils of undulating or rolling relief, partly because they are able to absorb and retain all of the limited annual rainfall, and partly because the slopes are not steep. Vegetation consists largely of shallow-rooted grasses and low shrubs, but only during years of favorable moisture conditions is there enough grass to afford good pasture for sheep.

The light reddish-brown, friable, but moderately fine-textured surface soil is normally calcareous. It is porous and easily penetrated by roots and moisture when disturbed and breaks into a weak blocky structure. The upper subsoil extends from an average depth of 8 inches to about 18 inches. It is composed of reddish-brown, slightly more compact clay loam or light clay that readily breaks into subangular blocky aggregates. Moisture penetration is facilitated by numerous well-preserved root holes and insect borings. Firm colloid-stained soil aggregates containing appreciable quantities of both segregated and disseminated lime are usually observed in this layer.

Lower in the profile, to depths of 40 inches or more, the subsoil is reddish brown, and higher in content of segregated lime than the material above. In this layer, porosity is reduced by compaction, and root and water penetration are definitely retarded. Small, somewhat rounded gravel is generally present throughout the soil mass, but usually there is more of it in the deep subsoil. The individual pebbles, generally coated with lime carbonate, are numerous enough to form closely packed and weakly cemented aggregates. The parent material, or underlying terrace deposit, is a highly calcareous light grayish-yellow or light reddish-brown gravelly clay or gravelly clay loam, firmly cemented in many places.

Los Banos soils are intimately associated with the extensive upland soils of the Kettleman series. In many places, Kettleman soils merge with and sometimes lie beneath a thin deposit of terrace material. The Ortigalita series, another group of associated soils, is similar to the Los Banos in color but differs otherwise. In the Ortigalita, the surface soil is noncalcareous, the subsoil is more compact, and the soil areas occur on small relatively steep fans that lie at the base of the flat terraces, and consist in part of material washed out from the terraces. Soils now classified in the Los Banos series were included in the Pleasanton series when the earliest reconnaissance survey of the Middle San Joaquin Valley (*3*) was made. As now classified, the Pleasanton series (*10*) has a narrower range in soil characteristics (*1*) and is not mapped in the Mendota Area.

Los Banos clay loam, undulating and rolling (6- to 20-percent slopes) (Ld).—This soil is confined to the northwestern part of the area in the vicinity of and bordering Little Panoche Creek. The relief is generally that of an undulating terrace, and the microrelief is slightly hummocky. In places, 3 to 6 percent slopes are included. Erosion is slight. Occasionally a shallow gully forms in the shallow swales.

The surface soil is a light reddish-brown or light-brown, friable clay loam, normally calcareous. Roots and water easily penetrate, and it breaks into a weak granular structure when disturbed. An upper subsoil, 6 to 12 inches thick, begins at an average depth of 8 inches. It is a reddish-brown, slightly more compact, calcareous light clay or clay loam. Moisture penetration is facilitated by numerous well-preserved root holes and insect borings. Small, firm soil aggregates coated with colloidal stains and containing appreciable amounts of segregated lime are usually present. In addition, there is disseminated lime. Below this layer and continuing to an average depth of about 40 inches, the subsoil is light reddish brown and moderately compact. Segregated and disseminated lime are both present in large amounts, and the porosity of the soil is sharply reduced by moderate density and compaction. Small rounded gravel occurs throughout the entire profile, but most of it is usually in the deep subsoil. The gravel is lime-coated, and locally the stones are numerous enough to become closely packed and weakly cemented together. The parent material, or underlying terrace deposit, encountered at depths of 30 to 60 inches, is a highly calcareous light grayish-brown or light reddish-brown gravelly clay loam, often firmly cemented into a conglomerate-like mass.

The vegetation on this soil is mostly short range grasses and a few scattered low shrubs. The grasses are pastured to sheep almost exclusively. During years of favorable rainfall, a fairly good stand of grass is produced.

Los Banos clay loam, steep (20- to 40-percent slopes) (Lc).—A much steeper relief, a more shallow and eroded profile, and a greater content of terrace gravel differentiate this soil from Los Banos clay loam, undulating and rolling. It occupies steep escarpments facing Little Panoche Creek and the deep ravines of nearby drainageways. It is easily eroded and gullied if mismanaged.

The surface soil is a light-brown or light reddish-brown, calcareous, friable clay loam that is moderately permeable to roots and water. It has an average thickness of about 4 inches and usually contains an appreciable amount of small rounded gravel. This gravel is more or less characteristic of the Los Banos series, and generally it is present in variable quantities throughout the profile.

The subsoil is a light-brown or light reddish-brown clay loam that extends to an average depth of about 24 inches. It is dense and compact, and the firm aggregates are coated with mineral colloidal stains. Root and water penetration are definitely retarded in the lower subsoil. Here, lime in both segregated and disseminated form is concentrated in appreciable quantities, and some of the closely packed gravel is weakly cemented. The underlying terrace deposit is highly calcareous and rather firmly cemented by lime carbonate and colloidal clay.

This soil supports only a poor to fair cover of short annual grasses and low shrubs, largely because seasonal rainfall is low and the slopes are steep and eroded. It is pastured to sheep whenever there is enough forage.

LOST HILLS SERIES

The Lost Hills soils have developed on old valley-filling material derived mainly from sedimentary rock. They occupy the older, well-drained parts of alluvial fans that occur at the base of the eastern side of the Coast Range. The main bodies of these soils are located short distances from stream channels, but they are free from recent alluvial deposition and have had sufficient time to develop a well-defined subsoil. Generally, the relief is very gently sloping, and a very decided hummocky microrelief is characteristic. The slopes range from 0 to 10 percent, the average being less than 3 percent. Erosion is usually slight, but it may be moderately severe on the steeper slopes. In this area, most of these soils are free of alkali or contain only slight quantities concentrated mainly in the subsoil. The native vegetation is range grasses and scattered low shrubs. Some burclover and filaree, or alfileria, are mixed with the grasses, but only in years of favorable rainfall will the grass cover afford better than fair sheep pasture.

A grayish-brown, noncalcareous, medium to moderately fine textured surface soil that breaks into a weak granular structure is typical of the Lost Hills series. The soil material between the mounds is puddled, hard and brittle when dry, and sticky when wet. In comparison, the soil material on the mounds is deeper, more friable when moist, and more easily penetrated by roots and water.

At an average depth of about 8 inches, there is a rather abrupt change to a light grayish-brown moderately compact and inter-

mittently calcareous upper subsoil. Internal drainage and root penetration are materially retarded by this layer. Lower in the profile, below depths of 16 to 20 inches, the subsoil is yellowish brown, highly calcareous, firm, and dense. The lime often is segregated in the form of soft nodules or small blotches, and in some places it lines the walls of small tubular pores. This layer develops a system of vertical and horizontal cracks on drying, and when the dry soil is disturbed it breaks into small, fairly firm, fine blocky aggregates. There is a considerable amount of colloidal staining on the surfaces of the aggregates.

The parent material, usually occurring at depths below 40 inches, consists of light yellowish-brown, calcareous, and somewhat stratified deposits. It is friable and coarser textured than the soil material above, but roots or moisture from rainfall seldom if ever penetrate to this layer.

The Lost Hills soils are associated with and are similar to those of the Ortigalita series in position, microrelief, profile development, and mode of formation. The parent materials are somewhat different, however, because the Ortigalita soils have developed on outwash from the reddish-brown Los Banos soils that lie above them. The parent material of the grayish-brown Lost Hills soils is derived from Kettleman and associated soil series. Lethent soil is locally associated with the Lost Hills, and it has some characteristics in common, such as parent material, mode of formation, and profile development. In the earlier reconnaissance survey of the Middle San Joaquin Valley (*3*) the Lost Hills series was included principally with the Antioch. The Antioch series is now held to a narrower range of soil characteristics (*10*) and does not occur in the Mendota Area.

Lost Hills clay loam, very gently sloping (0- to 3-percent slopes) (Lf).—Along the base of the foothills in the northwestern part of the area this soil occurs rather extensively. The general relief is broadly and gently undulating and the microrelief distinctly hummocky. Most of the soil is free of alkali or only slightly affected, but a few important areas have moderate accumulations. Surface drainage is slow but adequate. Gullying has occurred, but only slight recent acceleration in sheet erosion has taken place.

The grayish-brown noncalcareous clay loam surface soil, about 8 inches thick on the average, is hard when dry. It is neutral in reaction, low in organic-matter content, and moderately permeable to roots and water. It changes abruptly to a light grayish-brown upper subsoil which is moderately dense, intermittently calcareous, and slowly permeable to roots and water.

The highly calcareous deeper subsoil, beginning at an average depth of about 18 inches, is a yellowish-brown moderately dense clay that contains an appreciable quantity of segregated lime specks. When dry, a definite pattern of vertical and horizontal cracks is present, and firm blocky aggregates are formed when the soil is disturbed. The aggregates are heavily stained with collodial material and streaked with lime in mycelial form. The underlying parent material, usually encountered at a depth of about 40 inches, is a light yellowish-brown or very pale-brown calcareous and somewhat stratified sandy clay loam or heavy sandy loam. It is friable and coarser textured than the soil above, but plant roots and moisture rarely penetrate to this depth.

The vegetation is short range grasses mixed with burclover and filaree, or alfileria, and a few scattered low shrubs. During years of favorable rainfall, a good stand of grass provides a fair pasture until early in summer. Most of this soil is used for grazing sheep, but a substantial acreage in the northwestern part of the area is cultivated under irrigation. In areas free of or slightly affected by alkali, good or excellent yields of flax and grain are obtained if the soil is summer fallowed and green manured. Those areas that have moderate alkali accumulations give reduced yields and probably should be used for grazing.

Lost Hills clay loam, gently sloping (3- to 6-percent slopes) (LE).—This soil is very similar to Lost Hills clay loam, very gently sloping, except for its shallower profile, less distinct subsoil structure, and its occurrence on slightly steeper and more irregular slopes. Several small bodies are at the base of the lower foothills in the western part of the area, and a relatively large body occurs along the north bank of Panoche Creek near its junction with Silver Creek. The microrelief is distinctly hummocky. The soil is free of accumulations of alkali, or only slightly affected. Sheet erosion is slight, and there is practically no gullying.

The surface soil consists of a grayish-brown noncalcareous clay loam with a granular structure. It is neutral in reaction and low in its content of organic material. The underlying upper subsoil, beginning abruptly at a depth of about 6 inches, is a light grayish-brown to yellowish-brown, intermittently calcareous, moderately dense, firm clay loam. It is slightly more compact than the surface soil. About 8 inches deeper in the profile, it is underlain by the lower subsoil, a yellowish-brown moderately dense, firm clay that contains an appreciable quantity of segregated lime. This clay breaks into blocky aggregates that are noticeably stained with colloids. Below this lower subsoil at a depth of about 30 inches is a very light yellowish-brown or very pale-brown, friable, calcareous, somewhat stratified sandy clay loam or heavy sandy loam. It is usually dry, and only a few roots penetrate to this depth.

This soil is pastured to sheep, and the forage it produces is considered to be better than the average for the area. There is a fairly good stand of native grasses, mixed with some burclover and filaree (or alfileria) during years of favorable rainfall. None of the soil is under cultivation, primarily because of the expense of irrigation. Sheet erosion is only slight, and there is practically no gullying.

Lost Hills loam, very gently sloping (0- to 3-percent slopes) (LH).—Several representative bodies of this soil are located in the northwestern part of the area near Oro Loma. They are either free from alkali or contain moderate amounts. The microrelief is hummocky. There has been no appreciable erosion, but some of the soil has received occasional small deposits of fresh alluvial material.

The grayish-brown noncalcareous surface soil is a crumbly and friable loam, 8 to 14 inches thick, easily penetrated by roots and water. The intermittently calcareous upper subsoil is a light grayish-brown loam or clay loam, only slightly compact, and also permeable to roots and water. Below an average depth of 24 inches is a lower subsoil of light yellowish-brown or light-brown, calcareous, moderately compact clay of weakly developed prismatic structure. The surfaces

of the aggregates are stained with colloidal material and streaked with mycelial lime. The parent material is usually at a depth of 40 inches or more. It consists of a stratified, light yellowish-brown, calcareous sandy loam or loam that is massive and more friable than the soil above. In many places this parent material includes slightly calcareous layers of gravelly or very coarse sandy material.

The vegetation, mainly range grasses, burclover, filaree, and scattered low shrubs, provides a good stand of grass during years of favorable rainfall, and it is used as pasture for sheep. Where irrigation water is available and alkali accumulation is not a problem, good to excellent yields of flax and grain are obtained when fallowing and green manuring are practiced.

Lost Hills gravelly clay loam, sloping (6- to 10-percent slopes) (Lg).—Only one very small body of this soil occurs in the area; it is located in the extreme northwestern corner. The microrelief is distinctly hummocky. Sheet erosion is slight, and there are occasional shallow gullies.

The grayish-brown noncalcareous gravelly clay loam surface soil is friable. The well-rounded gravel is from 2 to 4 inches in diameter. The upper subsoil layer, beginning at an average depth of about 12 inches, consists of a light grayish-brown, noncalcareous, moderately compact gravelly clay loam. There is some vertical cracking, but gravel prevents formation of the distinct aggregates present in nongravelly soils of the same series. The lower subsoil is a yellowish-gray calcareous gravelly clay loam. It breaks into firm subangular blocky aggregates that are faintly coated with colloidal stains. Lime occurs in small seams or small soft nodules, in places associated with crystalline gypsum. The parent material, a yellowish-brown stratified gravelly clay loam or gravelly loam, is encountered at an average depth of 30 inches. It is porous and more friable than the soil material above and contains a small amount of segregated lime. Very few roots and practically no moisture penetrate to this layer.

The vegetation consists of short range grasses and scattered low shrubs. It provides fair sheep pasture during years of favorable rainfall. Because of the slope and lack of irrigation facilities in this area, none of the soil is cultivated.

MERCED SERIES

The Merced soils are derived from alluvial material from igneous and sedimentary rocks, which has been deposited in the nearly level parts of the valley basin. The soils are somewhat more advanced than the Temple soils in profile development. Where the two series are associated, Merced soils occur at elevations slightly higher than Temple soils. Surface drainage is very slow because the relief is almost level, and internal drainage is much retarded by the dense subsoil. Alkali is always present in varying quantities, mostly localized in the subsoil in moderate concentrations. Tules, swamp grasses, and saltgrasses comprised the native vegetation, most of which has been replaced by weeds and grasses that gained a foothold when the original cover was destroyed by cultivation or grazing.

Typical Merced surface soils are black or very dark gray, noncalcareous, fine-textured, and have a well-developed adobe structure. They are sticky and massive when wet but form large hard blocks

when dry. Noticeable quantities of small grit and micaceous material are mixed with the clay throughout the profile. The soil reaction is usually neutral or slightly basic.

The upper subsoil, beginning at an average depth of about 8 inches and extending to depths of 20 to 30 inches, is a black or very dark gray clay, generally containing segregated lime in small specks and soft accretions. It is compact and dense, and numerous vertical cracks show a definite prismatic structure. The firm soil aggregates and root channels are coated, apparently with colloidal material. Both water and root penetration are retarded in the upper subsoil.

The lower subsoil consists of olive-gray, highly calcareous, moderately dense clay that has only a few vertical cracks and a small number of roots.

The substratum, usually a plastic sandy clay loam, is highly calcareous and micaceous. The lime is generally segregated in nodules or soft gray seams that are weakly cemented into thin hardpanlike lenses in some places. The substratum is generally mottled with iron stains through the action of a recurrent high water table.

Merced soils are associated with the dark-colored Temple soils, which have less well developed profiles, and with the moderately developed, lighter colored soils of the Rossi series, which are normally high in salt content. Merced, Temple, and Rossi soils are similar in color, mode of formation, and general topographic position. In places where the Merced soils approach the Levis or other soils of the basin rim, particularly west and northwest of Tranquillity, the parent material contains more alluvium derived from the west side of the valley, and noticeable concentrations of gypsum generally occur in the subsoil.

Merced clay (adobe) (0- to 1-percent slopes) (MA).—This is the most common soil of the valley basin and the river flood plain. It occurs in large bodies throughout the basin area. West and northwest of Tranquillity, the parent material contains more alluvium derived from the west side of the valley, and the noticeable concentrations of gypsum generally occur in the subsoil. All of the soil contains soluble salt. Most of it is confined to the subsoil, however, and as long as it remains below the root zone, shallow-rooted crops can be economically cultivated. The relief is nearly level, available water-holding capacity is moderate, and erosion is negligible.

To an average depth of about 8 inches, the surface soil is a very dark-gray to black (moist), noncalcareous, dense clay. When dry, it develops an adobe structure and cracks into large blocks, many of which are 12 inches across. When wet, the soil swells and becomes very sticky. This surface layer is usually gritty and micaceous, and its reaction is neutral to slightly basic.

The upper subsoil, extending to depths of 20 to 30 inches, is a very dark-gray to black (moist) dense clay containing a considerable quantity of segregated lime in small specks and soft nodules or accretions. Surface cracks continuing into this layer give rise to a prismatic structure, and the well-developed aggregates are stained with colloidal material. Root and water penetration are definitely retarded.

The lower subsoil, to depths not exceeding 50 inches, is an olive-gray, highly calcareous, and moderately dense clay that contains a considerable amount of coarse grit and micaceous material. A variable quantity of crystalline gypsum may be present. In place, the

soil is massive, but when disturbed it breaks into subangular blocky aggregates that are smaller than the surface blocks. These aggregates are heavily stained with colloidal material and frequently mottled with rust-brown iron stains.

The substratum, usually composed of a plastic sandy clay loam material, ranges from light brown to olive gray, depending upon the prevailing ground water conditions. It is highly micaceous and calcareous. Lime occurs in nodular form. This layer is somewhat mottled with iron stains caused by the recurrent high water table.

Some of the native tules and swamp grasses still remain, but most of the soil has been under cultivation at some time, and the natural vegetative cover has been replaced by weeds and other plants. Where alkali conditions permit, fair to good yields are obtained from shallow-rooted field crops such as cotton, small grains, and barley if fallowing is practiced and barnyard manure is used occasionally. The soil is not suited to deep-rooted crops. Areas affected by moderate to strong concentrations of salts are best utilized as enclosed pasture for cattle during the winter months and the calving season.

Merced clay (adobe), shallow, over Traver soil material (0- to 1-percent slopes) (MB).—This soil consists of a moderately shallow profile of Merced soil over a substratum of calcareous sandy material similar to that of the Traver soil. The surface soil and part of the subsoil of Merced clay (adobe) rests abruptly on the sandy substratum of Traver material at depths of 24 to 36 inches. Relatively large bodies of this soil occur on the basin area, and all of them contain soluble salts in varying concentrations. The relief is nearly level, and drainage is a major problem.

The surface soil is a very dark-gray or black (moist) noncalcareous clay that forms large adobe blocks when dry. The similarly colored clay upper subsoil, beginning at a depth of about 8 inches, contains segregated lime and is moderately dense and considerably stained with mineral and organic colloids. Surface cracks extend into this layer and give rise to a definite prismatic structure that breaks into firm, blocky aggregates when disturbed. When wet, the clay swells and forms a very sticky mass. A substratum of brownish-gray highly calcareous sandy material abruptly underlies the dark clay at an average depth of about 30 inches. This material is similar to that of the Traver soil and extends to depths of more than 72 inches.

The soil is cultivated extensively to cotton and small grains, mainly barley. Fair to good yields are obtained where alkali accumulations permit, and alfalfa may be successfully grown in some areas. The areas strongly affected by salts are best used as saltgrass pasture. The native vegetation of tules and swamp grasses has largely been replaced by saltgrass and weeds.

Merced clay (adobe), shallow, over Willows soil material (0- to 1-percent slopes) (Mc).—This soil consists of a truncated profile of Merced clay (adobe) resting rather abruptly upon a substratum of material similar to that of the Willows soil. The soil is confined to a single body located along the northern boundary of the area. All of the soil is affected with varying degrees of alkali accumulation.

The soil has a typical Merced surface layer composed of very dark gray or black (moist) noncalcareous dense clay that develops a

pronounced blocky adobe structure when dry. The similarly colored clay subsoil begins at an average depth of about 10 inches. Moderately dense and highly calcareous, it exhibits a distinct prismatic structure.

A dark grayish-brown calcareous clay substratum begins abruptly at a depth of about 26 inches and extends to depths of 72 inches or more. It consists of alluvial material derived from both granitic and sedimentary rocks, but mainly from the latter. The clay is dense and breaks into large blocks that resemble the structural units of an adobe clay. It contains appreciable quantities of free lime and crystalline gypsum, is strongly mottled with iron stains, and resembles Willows soil material.

The soil is planted to rice and cotton where salt concentrations are sufficiently low. Elsewhere, it is utilized as saltgrass pasture. The native vegetation of tules, saltgrass, and swamp grasses has practically disappeared with the cultivation and partial drainage of the soil. Alkali, fine texture, and poor drainage are important in limiting successful cultivation. The dense clay subsoil and substratum further aggravate poor drainage and alkali accumulation and hinder operations that might benefit the soil.

ORTIGALITA SERIES

The Ortigalita soils have developed on old alluvial outwash, mainly from Los Banos soils on higher lying terraces, but partly from upland Kettleman soils. They occur on high, relatively short alluvial fans that project from the base of the terraces. These fans are somewhat older than the broad alluvial fans of the valley plain. Their relief is gently undulating, with slopes of 1 to 8 percent. The microrelief is distinctly hummocky. Surface runoff is slow to medium, and the more sloping soils are only slightly eroded. The vegetation consists mainly of annual grasses, with some burclover and filaree. Alkali in injurious quantities is not present, and the grass cover affords fair pasture for sheep during seasons of favorable rainfall.

The Ortigalita soils, distinguished by their brown noncalcareous surface layer, are usually moderately fine textured and friable. The surface soil is easily penetrated by roots and moisture and contains many well-preserved insect borings and root holes. The dry soil, when disturbed, forms weak granules that readily crumble. When wet, however, it tends to swell and become slightly sticky. There is usually a scattering of small partially rounded gravel on the surface and in places within the soil profile.

The upper subsoil, beginning at an average depth of about 11 inches, is composed of reddish-brown clay that is calcareous and moderately compact. Below this to a depth of about 36 inches is a light reddish-brown or light-brown lower subsoil that contains an appreciable quantity of segregated lime. The subsoil is moderately dense, and root and water penetration are definitely retarded.

Underlying the subsoil is either parent material or remnants of old terrace deposits that have been covered over with Ortigalita soil material. This substratum is variable in texture and in its depth from the surface. Generally, it is light gray, calcareous, and coarser textured than the soil material above. There are varying quantities of

gravel in it that may or may not be weakly cemented together. The substratum is closer to the surface in areas that lie near the base of the terraces than it is in areas farther out on the fans.

The Ortigalita soils are associated with and similar to those of the Lost Hills series in mode of formation, age, relief, and topographic position. Ortigalita soils are derived mainly from outwash from areas of Los Banos soils and are brown or slightly reddish brown. Lost Hills soils are derived from material washed from areas of the Kettleman soils, and they are grayish brown. Soils now classed in the Ortigalita series were included with the Pleasanton in the earlier reconnaissance survey of the Middle San Joaquin Valley (*3*). The Pleasanton series as now defined has a narrower range of characteristics (*1*) and is not mapped in the Mendota Area.

Ortigalita clay loam, very gently sloping (1- to 3-percent slopes) (OB).—North of Little Panoche Creek and adjacent to it, areas of this soil extend eastward from the low flat terraces. The general relief is very gently undulating, with a distinct hummocky microrelief.

This soil is characterized by an 11-inch surface soil of brown or slightly reddish-brown noncalcareous friable granular clay loam that is brittle when dry. Roots and water readily penetrate, and there are numerous well-preserved root holes and insect borings throughout. When wet, the soil tends to swell and become sticky.

The upper subsoil is reddish-brown, calcareous, and moderately dense. Below this to a depth of about 26 inches, there is a light reddish-brown clay lower subsoil that contains an appreciable amount of segregated lime. It is moderately compact, and there is a faint suggestion of vertical cracking which gives rise to weak prismatic structure. Root and water penetration are slow.

The underlying substratum appears to be an old terrace deposit that has been covered over by Ortigalita soil material. The depth to this terrace material varies greatly; it is nearest the surface in areas along the margin of the western foothills.

The vegetation of range grasses, burclover, and alfileria affords good pasture for sheep during the spring if rainfall is favorable. Surface drainage is slow, and no appreciable erosion or deposition has taken place in recent time.

Ortigalita clay loam, gently sloping (3- to 8-percent slopes) (OA).—More steeply sloping relief, a shallower profile, a relatively higher elevation, and the occurrence of more gravel in the subsoil layers distinguish this soil from Ortigalita clay loam, very gently sloping. Otherwise the two soils are very similar. Near the western boundary of the area, this soil extends eastward from the base of the low terraces that lie north of and adjacent to Little Panoche Creek. There is a pronounced hummocky microrelief.

The surface soil is a noncalcareous clay loam that is brittle but friable when moist. It averages about 6 inches in thickness and is readily penetrated by roots and water. The upper subsoil is light reddish-brown, calcareous, slightly more compact, and has a weakly developed prismatic structure. The lower subsoil, to an average depth of 24 inches, is a light-brown, highly calcareous, massive clay. Roots and water penetrate the lower subsoil with difficulty. There is more gravel than in the upper subsoil, and where it is closely packed, it is weakly cemented with lime and colloidal clay.

The underlying substratum is a compact, light-gray, highly calcareous gravelly clay loam in which rounded gravel is firmly embedded.

During seasons of favorable rainfall, a good stand of range grasses, burclover, and filaree is pastured by sheep. The low rainfall is readily absorbed, and the soil is held in place rather firmly by its vegetative cover. Sheet erosion is only slight, and there is almost no gullying.

OXALIS SERIES

The Oxalis soil occurs on alluvial deposits derived principally from softly consolidated calcareous and gypsiferous sandstones and shales. It has formed in basin-rim areas on the outer parts of the gently sloping fan of Panoche Creek where surface drainage is very slow. No appreciable amount of deposition or erosion is taking place at the present time. Most of this soil is affected by slight to strong concentrations of salts. Native vegetation consisted largely of a dense growth of grasses.

The Oxalis surface soil, about 14 inches deep, is dark brownish gray, fine-textured, and calcareous. It is very sticky when wet. When the dry soil is disturbed, it forms fine clods which can be worked to a suitable seedbed only by intensive cultivation. The soil puddles easily, but water and root penetration are aided by the lime content of the soil, which tends to flocculate the fine particles, and by the presence of numerous root holes and insect borings.

There is a gradual transition from the surface soil to a light brownish-gray or grayish-brown upper subsoil that averages about 18 inches in thickness. The upper subsoil contains moderate to large amounts of lime and gypsum, is normally fine-textured, and, depending upon moisture conditions, hard when dry or plastic when wet. This material grades into a fine-textured, light grayish-brown lower subsoil that is highly calcareous and gypsiferous. The substratum is very often stratified with fine silty material. In places where the downward movement of irrigation water has been arrested by these stratifications, a temporary perched water table has been created. The temporary water table causes a slight degree of rust-brown mottling in the soil mass.

The Oxalis soil is associated with the Panoche and Merced soils. The Panoche are well-drained soils occupying the higher elevations on the fans; the Merced are dark fine-textured soils of the basin. The Oxalis soil was included with the Panoche soils in the earlier reconnaissance surveys of the Middle and Lower San Joaquin Valley (*3*, *8*), but in the more detailed mapping and classification of soils in the Mendota Area these soils were recognized as a series distinct from the Panoche as now defined.

Oxalis silty clay (0- to 1-percent slopes) (Oc).—This soil is extensive west of Firebaugh and Oxalis (in Fresno County) along the outer edge of the broad Panoche Creek alluvial fan. The general relief is nearly level, and surface drainage is very slow. There is no erosion problem.

The 8- to 20-inch surface soil, a dark brownish gray silty clay, is difficult to maintain in good tilth when cultivated too wet. When allowed to dry out after an irrigation, it develops a structure somewhat like that of an adobe soil. It cracks deeply and forms hard 8- to 12-inch blocks. These blocks are partially broken down by an extensive system of secondary cracks. The moderate to large quantity of lime in the surface soil gives it a slightly basic reaction.

The upper subsoil is a light brownish-gray or grayish-brown silty clay that contains large quantities of lime and gypsum. The lower subsoil, found at depths of 20 to 44 inches, is light grayish-brown silty clay. It usually contains a considerable amount of free lime and crystalline gypsum. Some stratification of coarser material frequently occurs in areas bordering large bodies of Panoche soils. In such areas the substratum is usually light brown, mildly calcareous, and friable. The native and cultivated vegetation are shallow-rooted. Annual rainfall is low, and roots and water rarely penetrate to the deeper subsoil.

Most of the natural vegetation of grasses and alkali-tolerant shrubs disappeared during intensive cultivation. Where alkali concentration permits, fair to good yields of flax, cotton, rice, and other small grains are obtained (pl. 1, *B*). Good quality alfalfa has also been grown successfully. Consistent yields can be maintained if fallowing and green-manuring practices are employed. Alkali concentrations range from slight to strong. Most of the soil is affected with moderate amounts of alkali, which limits suitability for agriculture. Because most of the salts are localized in the subsoil, shallow-rooted crops are not greatly affected.

PANHILL SERIES

Panhill soils have developed on young alluvial materials derived from areas of the same softly consolidated calcareous and gypsiferous sedimentary rocks that give rise to the Kettleman soils, which lie in the lower foothills to the west. They normally occupy interfan areas situated equally distant from the hill land and the valley trough. (pl. 2, *A*). The characteristic relief is gently sloping and slightly hummocky. Erosion is slight, mainly because the permeable soils readily absorb both the low seasonal rainfall and the runoff from the uplands. Areas of these soils that have received recent alluvial depositions are described as a shallow phase of Panoche soil over Panhill soil material. Most of the soils are free from alkali, but there are some relatively small areas with slight or moderate concentrations. The vegetation is range grasses mixed with burclover and filaree.

The Panhill series is composed of a group of brownish-gray, pale-brown, or yellowish-brown soils. The medium to moderately fine textured surface soil is friable, noncalcareous, and weakly granular. Slight vertical cracking occurs when the soil is thoroughly dry. The surface layer is porous and easily penetrated by roots and water. The upper subsoil, beginning at an average depth of about 8 inches and ranging from 6 to 14 inches in thickness, is clearly distinguished from the surface soil by its slightly browner color and its accumulation of lime carbonate. The light-brown to light yellowish-brown underlying material, to depths of 60 or more inches, is moderately calcareous, and often coarser textured than the soil layers above. It may include stratified silty material in which there is an occasional thin sandy layer.

The Panhill soils are similar to the associated recent alluvial Panoche soils, but in a slightly more advanced stage of development. This development is manifested by a definite zone of lime accumulation in the upper subsoil. They are also closely associated with the more fully developed Lost Hills soils, the microrelief of which is markedly hummocky. The Panhill series has some characteristics common to

both the Lost Hills and the Panoche soils. In the broader soil classification of the earlier reconnaissance survey of the Middle San Joaquin Valley (*3*), the Panhill soils were usually included with the Panoche.

Panhill clay loam, very gently sloping (0- to 3-percent slopes) (Pb).—Most of this soil is free of salts, but some is slightly affected. There are several widely separated bodies, the largest of which lies 2 miles south of Oro Loma. The microrelief is hummocky.

The surface soil, averaging 11 inches in thickness, is a brownish-gray or yellowish-brown clay loam that breaks into weak hard granules if disturbed when dry. It is noncalcareous, nearly neutral in reaction, and low in content of organic matter. Root and water penetration are facilitated by the numerous well-preserved root holes and insect borings that permeate this layer.

The upper subsoil is distinguished from the surface soil by small quantities of disseminated lime and by weak vertical cracking in the soil mass. This layer is generally yellowish-brown clay loam and moderately permeable to roots and water. A characteristic zone of lime accumulation about 8 inches thick occurs at a depth of approximately 20 inches. At this depth, the upper subsoil is a light yellowish-brown clay loam and slightly more compact.

The lower subsoil, to variable depths of less than 50 inches, is less calcareous than the layer above, but in many places it contains thin, highly calcareous silty strata. Occasionally a few gypsum crystals are present in this lower layer.

The substratum is light yellowish-brown or in places yellowish-brown, calcareous, stratified sandy clay loam or sandy loam. This extends to depths of 72 inches or more. It is friable and easily penetrated by roots and water but is rarely moist because the annual rainfall is too low.

The vegetation, consisting of a variety of short range grasses, burclover, and filaree, provides good sheep pasture in spring if rainfall is favorable. The hummocky relief is easily leveled; and, where irrigation water is available, crops such as flax, cotton, and grain are cultivated. Excellent yields are obtained so long as the land is fallowed and green-manured. Erosion is not a problem, but a few areas occasionally receive small deposits of fresh alluvium. Care should be taken in irrigated areas, because the soil will erode and gully under careless water management.

Panhill clay loam, gently sloping (3- to 6-percent slopes) (Pa).—This soil is similar to Panhill clay loam, very gently sloping, but the surface soil is shallower, the zone of lime accumulation in the subsoil is more concentrated, and the hummocky microrelief is often more pronounced. A moderately extensive area lies between the Panoche Hills and the county highway south of Little Panoche Creek. The soil is free of injurious accumulations of alkali.

To an average depth of 6 inches, the surface soil is a yellowish-brown or brownish-gray, friable, noncalcareous clay loam that breaks into weak granules if disturbed when dry. Numerous well-preserved root holes and insect borings are present. The upper subsoil is slightly calcareous and shows vertical cracking. It may be both plastic and sticky when wet. A 6- to 7-inch zone of lime accumulation is usually encountered at a depth of about 14 inches, and here the clay loam sub-

soil is slightly more compact. Root and water penetration are not seriously retarded, however. The substratum, extending from a depth of about 30 inches downward to 72 or more inches, is less calcareous than the surface soil and more friable. It is light brownish-gray or light yellowish-brown, and some stratification of highly calcareous silty or sandy material may be present. This lower material is similar to that of Panhill clay loam, very gently sloping.

The quality and extent of the annual range grasses, burclover, and filaree that grow on this soil depend on the seasonal rainfall, but it is extensively pastured by sheep and the grazing value is considered to be better than the average for the area. None of the soil is under cultivation because irrigation facilities have not yet been developed. Sheet erosion is generally slight, and no gullying of any consequence was taking place at the time of survey. The soils would erode and gully under careless irrigation management.

Panhill silt loam, very gently sloping (0- to 3-percent slopes) (PD).—One large body of this soil occupies an interfan area lying between the terminus of Little Panoche Creek and the county highway, and small areas occur further south. The microrelief is hummocky. More than 75 percent of this soil is free of injurious accumulations of alkali; the remaining area is only slightly affected.

The pale-brown or yellowish-brown noncalcareous silt loam surface soil averages about 10 inches in thickness. Friable and permeable, it breaks into weak granules if disturbed when dry. When moist, the soil is browner than when dry and tends to become plastic or sticky when wet. The pale-brown or light yellowish-brown clay loam or silt loam upper subsoil is distinguished from the surface soil by disseminated lime and weak vertical cracks. Well-preserved root holes and insect borings permeate this layer and aid in root penetration and moisture percolation.

Lower down, but not exceeding 30 inches in depth, the clay loam subsoil is browner than the surface soil, and there is a definite zone of accumulated lime, 6 to 9 inches thick. Here, the subsoil is slightly more compact, but it does not materially restrict root and moisture penetration. This layer is underlain by a material similar to that of the substratum of Panoche clay loam. It continues to depths of 60 or more inches and is frequently stratified with a highly calcareous silty material that may contain small amounts of crystalline gypsum. The color of this uniformly friable and calcareous layer ranges from light brownish gray to yellowish brown.

Only a small acreage of this soil has been cultivated, largely because of the lack of irrigation facilities. The hummocky surface is easily leveled for irrigation, and excellent yields of crops, such as flax, small grains, and barley can be obtained. For consistent results the soil should be regularly fallowed and a green manure crop occasionally grown. Under natural conditions, erosion is not a problem, but the soil would erode and gully if it were improperly irrigated. During seasons of favorable rainfall, a good stand of range grasses, burclover, and filaree provides sheep pasture that remains better than the average for the area until late in spring or early in summer.

Panhill silt loam, gently sloping (3- to 6-percent slopes) (Pc).—In most respects this soil is similar to very gently sloping Panhill silt loam. It differs mainly in its more pronounced hummocky micro-

relief, its slightly shallower profile, and in its greater slope. A typical body is south of Little Panoche Creek at the county highway. All of the soil is free of alkali.

The surface soil averages 7 inches in thickness and is a pale-brown or yellowish-brown, noncalcareous, friable silt loam that breaks into weak granular aggregates if disturbed when dry. The wet soil becomes plastic or sticky. The soil is nearly neutral in reaction and contains a low amount of organic material.

The subsoil is a light grayish-brown calcareous clay loam, in the lower part somewhat stratified with sandy or silty material. A definite zone of lime accumulation about 8 inches thick usually occurs at a depth of approximately 16 inches. The subsoil is compact, but numerous well-preserved root holes and insect borings permeate the soil mass and facilitate root and moisture penetration. Below 30 or more inches, it is light brownish gray or yellowish brown, generally medium-textured, more friable than the soil in the layers above, and only mildly calcareous. It may contain some crystalline gypsum.

The cover of range grasses, burclover, and filaree is pastured by sheep. During seasons of favorable rainfall, forage better than average for the area grows until late in spring or early in summer. None of the soil is cultivated, because irrigation facilities have not yet been developed. The agricultural potentialities are about equal to those of very gently sloping Panhill silt loam. Sheet erosion is slight at present, and no serious gullying is developing. The soil, however, would erode if improperly cultivated and irrigated.

PANOCHE SERIES

The Panoche soils consist of recently deposited alluvium that originates principally from the areas of softly consolidated calcareous and gypsiferous sandstones and shales that give rise to the Kettleman soils of the Coast Range foothills. The Panoche soils generally have a gently sloping smooth relief, but in some uncultivated places the microrelief is slightly hummocky. In this area, they occur in relatively large bodies, most of which are on the alluvial fan of Panoche Creek. The vegetation, principally short annual grasses, affords fair sheep pasture during the spring and early in summer in years of favorable rainfall. Erosion is negligible, but a few large areas in the vicinity of Panoche Creek periodically receive small deposits of silty alluvial material from floodwaters. Because of low annual rainfall and permeable nature of the soils, runoff is usually readily absorbed. Large areas of these soils are free of alkali or only slightly affected, but some fairly large bodies contain moderate quantities of salts.

The surface soil of the Panoche series is light brownish gray, light yellowish brown, or pale brown, calcareous, and widely variable in texture. It is thick and friable, and easily penetrated by roots and water. Where the soil is moderately fine textured, it becomes sticky when wet but is easily worked when dry. The subsoil, to depths in excess of 6 feet, is very similar to the surface soil. There may be an increase of lime content in a segregated form and small quantities of gypsum, but there is no definite development of structural units. Usually, the subsoil is browner or yellower than the surface soil and somewhat stratified with silty and coarse-textured material. Moisture easily penetrates deep into the soil. It is well retained in the finer textured surface soil but readily lost through evaporation and transpiration in the coarse textured.

Closely associated with the Panoche soils are the Lost Hills and Panhill, which are similar in color and mode of formation but somewhat older and more advanced in profile development. The grayish-brown very slowly drained Oxalis soil in the basin-rim areas, and also the soil of the alkali-affected Lethent series, are closely associated with the Panoche. Most of the Panoche soils are under cultivation and highly productive.

Panoche silty clay (0- to 3-percent slopes) (Pn).—This friable, fine-textured soil, one of the most extensive in the area, occurs in large bodies in the central part. Most of it is slightly affected with alkali, and some areas contain moderate accumulations. A substantial acreage, however, is alkali-free. A slight deposition of alluvial material rather than erosion has taken place in some areas.

The 14- to 20-inch surface soil is light brownish-gray, light yellowish-brown, or pale-brown, calcareous, friable silty clay. When dry, irregular surface cracks develop and the soil breaks into fine clods if cultivated. It is easily puddled and very sticky when wet. The subsoil is light yellowish brown or pale brown highly calcareous silty clay. Root and water penetration are facilitated by numerous root holes and insect borings. In a number of places, particularly where the soil borders Oxalis silty clay, there are moderate quantities of gypsum. Beginning at an average depth of 42 inches and continuing to depths in excess of 72 inches, the substratum is often somewhat darker colored than the surface soil and is frequently stratified with medium- or coarse-textured sediments. The quantity of lime and gypsum is variable but never excessive.

A large acreage of this soil is dry-farmed or irrigated. Dry farming is limited to the growing of grain in areas that receive some floodwater from creeks. Yields are only fair during seasons of favorable rainfall. Irrigated crops, such as flax, cotton, grain, and small acreages of vegetables and melons, produce well where the soil is fallowed or green-manured consistently. The generally smooth surface is easily prepared for irrigation, and drainage is good. Noncultivated areas support a cover of range grasses, including an appreciable amount of burclover and filaree. The cover affords good pasture for sheep during the spring months. The soil is highly susceptible to erosion and gullying if irrigation water is not properly managed. If too large a head of irrigation water is turned into an unchecked ditch on a long downgrade, a damaging gully is almost certain to develop.

Panoche silty clay loam (0- to 3-percent slopes) (Po).—In the very gently sloping central part of the area, particularly in the vicinity of Panoche Creek, this soil occurs extensively. Surface drainage is slow and there is little erosion under natural conditions. About half of this soil is affected by slight accumulations of alkali; the rest is alkali-free.

The surface soil, averaging 18 inches thick, is a light brownish-gray, pale-brown, or light yellowish-brown, calcareous, friable, weakly granular silty clay loam.

It is very sticky when wet. Moisture is rapidly absorbed and well-retained against evaporation under natural conditions. The surface soil grades into a similar but browner subsoil. It may contain both segregated and disseminated lime. The substratum, extending to a

depth in excess of 72 inches, is often stratified with coarser materials, and it may contain slight amounts of gypsum. The profile is relatively uniform throughout, and roots and water easily penetrate deeply.

Most of this soil is cultivated under irrigation. Excellent yields of flax, grain, cotton, and milo are obtained in areas free from alkali if a program of fallowing and green-manuring is followed consistently (pl. 3). Yields are somewhat reduced in areas of slight alkali accumulation. In years of favorable rainfall, dry-farmed grain can be grown successfully in those places where some spreading of the floodwater from small creeks is possible, but yields vary a great deal and are generally low. On the uncultivated land, a cover of range grasses, burclover, and filaree provides a good pasture for sheep in the spring. The vegetation depends upon the seasonal rainfall, however, and extremely dry years are frequent. The soil would erode and gully badly under improper irrigation management. Some areas, especially those in the vicinity of the larger streams, occasionally receive a small deposit of fresh alluvium during rainy periods.

Panoche silty clay loam, shallow, over Lost Hills soil material (0- to 3-percent slopes) (Pp).—This is essentially a Lost Hills clay loam profile buried by an overwash of Panoche silty clay loam. The layer of overwash is light yellowish brown or light brownish gray. It varies from very thin to nearly 24 inches thick, depending on the surface over which it has been deposited. The overwash is deepest in the flat areas between the characteristic hummocks of the Lost Hills soils and thinnest where it caps the hummocks. The microrelief is slightly hummocky where overwash did not completely cover the Lost Hills mounds. Rather than erosion, slight deposition of fresh Panoche material takes place during times of abnormally high rainfall. About half of the soil is free of alkali, and the rest is affected mainly by slight concentrations. Several good examples of this soil extend eastward from the base of the low-lying foothills between Panoche and Little Panoche Creeks.

The overwashed surface soil, calcareous and friable, rests abruptly on a profile of Lost Hills clay loam, the upper part of which is like the typical surface soil of the Lost Hills clay loam in its average depth of about 8 inches. Unlike typical Lost Hills clay loam surface soil, this has a yellowish-brown color and an appreciable content of disseminated lime. This layer is followed by a light yellowish-brown or light brownish-gray moderately compact clay loam that breaks into blocky aggregates when disturbed. There is a gradual transition to only mildly calcareous, yellowish-brown, friable parent material that is usually stratified with coarse-textured sands.

Grasses and shrubs grow well whenever seasonal rainfall is sufficient. Most of this forage is pastured by sheep. Where it is possible to spread some floodwater from creeks, some of the soil is dry-farmed to grain or grain hay. The soil could be leveled easily; and, if irrigation facilities were available, good crops of grain and flax could be produced where the soil is free of injurious concentrations of alkali.

Panoche loam (0- to 3-percent slopes) (Pk).—Small- to medium-sized bodies of this soil are located along the very low ridges scattered over the area in which Panoche soils occur. In many places the soil

occupies a slightly elevated ridge that marks the position of a former stream channel. Most of the soil is free of alkali, but a considerable part is slightly affected.

The 20-inch surface soil consists of pale-brown, light brownish-gray, or light yellowish-brown calcareous loam that is porous and friable. There is some variation in the texture of this surface soil, and it is nearly a silt loam in some places. In cultivated areas the coarse and fine materials have been so mixed that the average texture is a loam. The subsoil and substratum to a depth of 72 or more inches is usually composed of alternating fine- and coarse-textured strata. The fine-textured layers are a shade darker than the coarse. They are very silty and have a thin platy structure. The fine-textured layers slow the downward movement of water in the subsoil and thereby benefit shallow-rooted crops. Deep-rooted plants might experience a slight disadvantage in root development.

Where irrigated, this soil produces good yields of flax, cotton, and grain, and a limited number of climatically adapted truck crops (pl. 4, *A*). To maintain production, it is important to fallow the soil regularly and to treat it occasionally with a green-manure crop. A good stand of grasses, burclover, and filaree grows in the spring. This forage is pastured by sheep in the areas where irrigation is not available. Deposition of fresh alluvial material rather than erosion occurs in some places at irregular intervals, but the soil would erode and gully if it were carelessly cultivated and irrigated. Many reservoirs for storage of pumped water have been constructed on this soil because of its elevated position.

Panoche fine sandy loam (0- to 3-percent slopes) (Pg).—Rather large areas of this very gently sloping soil occur adjacent to stream courses, or as long narrow bodies marking the position of former drainage channels that once extended far out on the fan into areas of Panoche silty clay and silty clay loam. Most of the soil is free of alkali, but areas of slight accumulation do occur. The soil may receive occasional depositions of alluvium, especially in areas adjacent to shallow drainage channels.

To an average depth of about 18 inches, the surface soil is a pale-brown or light yellowish-brown, calcareous, friable fine sandy loam. It is underlain by a calcareous very pale-brown or very light yellowish-brown loam, sandy loam, or silt loam that is usually stratified with silty clay loam or a lighter (coarser) textured material. Especially in the vicinity of Panoche Creek, the subsoil is stratified with coarse-textured layers that allow rapid internal drainage. In other areas, farther removed from the main streams, the subsoil strata are more predominantly silty clay loam and prevent rapid percolation of irrigation and rain water. Below a depth of about 30 inches, the pale-brown or light yellowish-brown substratum is more uniform in texture. It is a fine sandy loam or loam containing slight but visible quantities of segregated lime in addition to lime in the disseminated form. This friable material extends to depths in excess of 72 inches; it rarely receives moisture except in heavily irrigated areas or during unusual rainstorms.

Much of the irrigated Panoche fine sandy loam is used to grow cotton and flax and it is also suitable for most of the crops that are adapted to the climate of the region. Where free from alkali or

even slightly affected, good to excellent yields are obtained consistently if the soil is regularly fallowed and occasionally green-manured. When cultivated, the soil is subject to erosion and gullying if irrigated improperly.

Panoche clay loam (0- to 3-percent slopes) (Pe).—Bodies of this soil are scattered throughout the central part of the area. They usually occur in areas of transition between Panoche loam or fine sandy loam and Panoche silty clay or silty clay loam. No appreciable erosion has taken place, but near stream channels the soil occasionally receives deposits of fresh alluvium. Much of the soil is slightly affected by alkali. A relatively large part is alkali free, however, and a much smaller part contains moderate concentrations.

The calcareous surface soil, usually light brownish gray, light yellowish brown, or pale brown, extends to depths of 10 to 36 inches, the average depth being about 22 inches. It is friable and can be worked easily to a good seedbed when sufficiently moist. Organic-matter content is low. There is a gradual transition to a uniformly light yellowish-brown clay loam subsoil that is easily penetrated by roots and water. Some segregated lime, together with a small amount of crystalline gypsum, may be present in the lower subsoil, which is frequently stratified with medium- or light (coarse)-textured materials.

Panoche clay loam is extensively cultivated to general field crops such as cotton, wheat, barley, and flax wherever irrigation water is available. It is occasionally used for dry-farmed grain during seasons of favorable rainfall in places where some floodwater from small creeks is available. Excellent crop yields are obtained under irrigation if the soil is regularly fallowed and occasionally green-manured, but dry-farmed yields are only fair because of the low and uncertain annual rainfall. Alkali accumulations and local weather conditions are the principal factors limiting crop selection and yields. Uncultivated areas produce a good growth of range grasses, burclover, and filaree, which provide sheep pasture in the spring. This soil is susceptible to erosion and gullying, which may become serious under improper irrigation and tillage.

Panoche clay loam, shallow, over Panhill soil material (0- to 3-percent slopes) (Pf).—This soil consists essentially of a layer of recent Panoche clay loam material of variable thickness deposited upon a profile of Panhill clay loam. Several small areas are located along the base of the lower foothills north of Panoche Creek within larger bodies of very gently sloping Panhill clay loam. All of the soil is free of injurious concentrations of salts. The hummocky microrelief characteristic of the Panhill soils is absent or obscured by overwash material. Deposition rather than erosion is active at present, and recent clay loam deposits containing a considerable amount of silt are clearly distinguishable.

The overwash of Panoche clay loam material is light brownish gray or light yellowish brown, calcareous, and friable. It is 6 to 30 inches thick, and it greatly modifies the hummocky microrelief characteristic of the Panhill soils. Deposition is deepest between the mounds, but in many places it is not sufficient to cover the tops completely. The material that normally would be the surface soil of Panhill clay loam is yellowish brown, friable, and slightly calcareous instead of

noncalcareous. At a depth of about 40 inches, there is an 8-inch zone of segregated lime accumulation, and the soil is slightly more compact. Root and water penetration are not seriously retarded, however. Immediately below this layer, the soil is more friable and generally medium-textured. Some stratified silty or sandy material, often highly calcareous, is usually present. It contains an occasional deposit of crystalline gypsum.

None of the soil is cultivated. It supports a growth of shrubs, range grasses, and other plants extensively used for sheep pasture. During years of favorable rainfall, good forage is maintained from late in winter to late in spring. The soil will erode and gully during heavy storms if the plant cover is destroyed.

Panoche silt loam, shallow, over Lost Hills soil material (0- to 3-percent slopes) (PM).—This soil consists of an overwash of Panoche silt loam on a substratum of Lost Hills clay loam. The hummocky surface of the Lost Hills soil has been covered by an overwashed layer of Panoche material that may be very thin or as much as 24 inches thick. A large body extends eastward from the base of the lower foothills about 2 miles north of Panoche Creek, and another similar body lies just south of Little Panoche Creek. All of the soil is free from injurious concentrations of salts. The microrelief is slightly hummocky. The soil has occasionally received small depositions of fresh alluvium, particularly during years of unusually heavy rainfall.

The surface soil is a light yellowish-brown or light brownish-gray friable silt loam that contains appreciable quantities of disseminated lime. This is underlain by a profile of Lost Hills clay loam material that differs from typical mainly in its darker color in the upper part (the former surface soil) and in its content of moderate quantities of disseminated lime. It has a moderately dense subsoil containing segregated as well as disseminated lime. The light yellowish-brown, calcareous, stratified Lost Hills parent material does not occur within the usual 6-foot profile except in places where the overwash is very shallow.

This soil produces a good growth of grasses and low shrubs during seasons of sufficient rainfall, and most of it is pastured by sheep. Good to excellent yields of flax and grains are obtained under irrigation if the soil is fallowed and occasionally treated with a green-manure crop. Some leveling of the hummocky microrelief is required before irrigation.

Panoche gravelly loam (0- to 3-percent slopes) (PH).—A few small isolated areas of this soil lie adjacent to Panoche and Little Panoche Creeks. All of the soil is free of injurious accumulations of alkali. Erosion is not a problem, and nearly all of the soil has received small deposits of alluvium during recent times.

The surface soil, 4 to 14 inches deep, is a light brownish-gray or light yellowish-brown, calcareous, friable gravelly loam that contains an appreciable quantity of silty material. In places, its texture is nearly that of a gravelly clay loam. The gravel is small, and the quantity generally increases with profile depth. Root and water penetration are facilitated by numerous root holes and insect borings. The underlying subsoil is a friable, light yellowish-brown or pale-brown, medium-textured material stratified in many places with layers of loamy sand or coarse sand. The soil material itself is only

mildly calcareous, but the gravel is usually coated with a thin veneer of lime carbonate. The substratum below depths of 50 or more inches, is very gravelly and calcareous, and in some places it contains small deposits of gypsum.

Although this soil is free of alkali, very little of it is cultivated, because irrigation facilities are lacking. Only a small area southwest of Oro Loma is irrigated. Along Panoche and Little Panoche Creeks, bodies of this soil receive seepage water that maintains a green pasture for sheep until late in summer. Occasionally, this pasture is augmented by the seeding of grain.

Panoche loamy fine sand (0- to 3-percent slopes) (Pl).—Several bodies of this soil are located far out on the broad Panoche Creek fan near the end of Panoche Creek. It is entirely free of alkali. No appreciable sheet erosion or gullying has occurred, but in a few places there has been an occasional deposition of alluvium.

The calcareous surface soil, from 8 to 30 inches deep, is pale brown or light yellowish brown and loose. The subsoil is a pale-brown or light yellowish-brown sandy loam, silt loam, or loamy sand that is calcareous and generally stratified. The stratifications vary widely in texture from loose sands to clays and silty clays that contain an appreciable quantity of free lime. Below 40 inches, the substratum is more uniform. It is a calcareous, very porous, pale-brown fine sand or sandy loam. The loose and generally open condition of the subsoil results in rapid to very rapid internal drainage and a low available water-holding capacity.

Very little of this soil is cultivated, largely because it requires a large amount of water in a region where irrigation water is costly. Some sheep pasture is provided by range grasses during years of sufficient rainfall. In its natural state, the soil is cut by many small stream channels, but some of these have been obliterated by cultivation. In such areas, the texture of the surface soil is highly variable.

RIVERWASH

Riverwash (Ra) is a poorly assorted mixture of the gravel and loose sands that occurs along the larger stream channels. Although this miscellaneous land type is essentially nonagricultural, a few of the more favorable areas are the source of some water for stock, and the few trees that grow in these areas provide some shade.

ROSSI SERIES

Rossi soil is derived from alluvial sediments, mainly of granitic rock origin, that have been deposited in basin areas near the San Joaquin River. The soil has a moderately developed profile that reflects poor drainage and an almost constant high water table. The surface is nearly level, and surface drainage is very slow. Erosion or deposition has not been active during recent times. The Rossi soil in this area is affected by strong concentrations of alkali, most of which is in the subsoil. The vegetative cover consists mainly of saltgrass and other salt-tolerant plants.

The surface soil is slightly calcareous, gray or dark-gray, blocky, moderately fine textured, moderately high in organic matter, and sticky when wet. It rests abruptly at very shallow depths on a dark-gray, moderately fine textured upper subsoil which is compact, dense,

and has a moderately developed prismatic structure. There is some segregated lime in this layer, and noticeable amounts of gray mottling and colloidal stains are apparent on the surfaces of the firm aggregates.

At depths below 20 inches, the subsoil is massive and less compact. The color changes to olive gray, and the soil is highly mottled with rust-brown stains due to the high ground-water level. The lower subsoil is gritty and micaceous. It contains small lime pellets or concretions, and in places there are appreciable quantities of gypsum. The underlying substrata are light yellowish-brown calcareous sandy clay loam materials very similar to those that underlie practically all of the soils of the basin area.

The Rossi is closely associated with the Merced series, which has a similar profile development. The Merced soils are darker colored, however, and they occupy a slightly lower position that was more susceptible to overflow in the past. The upper and lower subsoil layers of the Rossi series are not so dark colored as those of the Merced. Rossi soil was included with the Stockton in the earlier reconnaissance survey of the Lower San Joaquin Valley (*8*).

Rossi clay loam (0- to 1-percent slopes) (RB).—This soil occupies nearly level basinlike areas. All of it is strongly affected by accumulations of alkali. It is slowly permeable to moisture, and the water table is frequently high. The largest areas are 2 miles southeast of North Camp.

To an average depth of about 8 inches, the surface soil is a gray or dark-gray blocky clay loam, moderately high in organic matter and generally slightly calcareous. Many small roots and saltgrass stolons are present. The upper subsoil is a dark gray, calcareous, moderately compact, sandy clay loam. It has a fairly well developed prismatic structure with a considerable amount of gray mottling and colloidal staining of the firm aggregates and an occasional faint streak of black. Some segregated lime is usually present.

Below a depth of about 20 inches, the lower subsoil is massive but only slightly compact. It is olive gray and highly mottled due to a more or less constant high water table. There are many small lime pellets or concretions in this layer. It is gritty, micaceous, and contains variable quantities of crystalline gypsum. The underlying substrata, beginning at an average depth of about 48 inches, consist of yellowish-brown calcareous sandy clay loam material that is micaceous and in other respects similar to the substrata underlying most of the basin soils.

In this area the native cover of saltgrasses and other salt-tolerant plants has been altered somewhat by several attempts to cultivate the soil. No crop has as yet been economically successful, mainly because of the high alkali content. Reclamation would be difficult because of the flat basinlike relief and the very slowly permeable nature of the subsoil. Some use can be made of the soil as a saltgrass pasture.

ROUGH BROKEN LAND

Rough broken land (Rc) consists of rolling to hilly upland areas badly dissected by natural erosion. It is possible that this miscellaneous land type conforms to a fault zone and rather recent geologic disturbances. Several representative bodies are located in the foothills of the western part of the area where Silver Creek joins Panoche Creek.

The soil material is very shallow, the depth rarely exceeding 8 inches, and it consists of a purplish-gray clay loam mixed with large quantities of small platy fragments of shale. It is slightly acid, an unusual condition considering the dry climate of the area. The acidity of the soil results from the slightly acid underlying shale rock. The shale is weakly consolidated, shattered, noncalcareous, purplish in color, and in a few places it is stratified with bands of yellowish-brown noncalcareous sandstone and thin seams of clear or almost transparent gypsum. Near the surface, many of the shale fragments are coated with a yellowish material, possibly limonite.

Vegetation is very sparse and consists mainly of shallow-rooted annual grasses. A nutrient deficiency appears to be one factor that limits the growth of plants. The sparse plant growth contributes to the high erodibility of these areas. Sheep are grazed to some extent; but, even during seasons of favorable rainfall, the amount of forage hardly warrants pasturing. It is closely associated with the Kettleman soils but is distinct from them, particularly in the purplish color of the soil material.

TEMPLE SERIES

The Temple soils are derived from granitic alluvium that has been deposited in the nearly level basinlike areas near the San Joaquin River. There is no evidence that recent deposition of alluvial materials has taken place. Surface drainage is very slow, and internal drainage is slow. The soils are normally affected by a high water table. Slight or moderate amounts of alkali occur. The native vegetation consisted principally of tules and swamp grasses.

The surface soil is dark gray or black, friable, noncalcareous, and moderately fine to fine textured. It contains large quantities of organic matter, is nearly neutral in reaction, and is easily penetrated by roots and water. A weak blocky structure is formed when the dry soil is disturbed. It is very sticky when wet.

The upper subsoil, beginning at an average depth of 10 inches, is a very dark-gray or black friable silty clay or clay loam that contains variable but generally moderate quantities of lime and organic material. Below a depth of about 24 inches, the lower subsoil is a clay or clay loam that is darker brown in color, moderately to highly calcareous, and slightly more compact. There is noticeable gray and rust-brown mottling of the soil, and the soft aggregates are stained with mineral and organic colloids. An olive-gray or light olive-gray highly calcareous sandy clay loam substratum with dull mottling is reached at a depth of about 50 inches. This part of the profile appears to have been under water for longer periods of time than that above, and it is similar to the substrata underlying other soils of the basin. In places the substratum is stratified with coarser textured micaceous material.

The associated basin soils include members of the Merced and Columbia series. The Merced series is composed of soils with moderately compact subsoil. The Columbia series is made up of light grayish-brown soils derived from recent medium-textured granitic alluvial materials deposited along the San Joaquin River. In the early reconnaissance survey of the Lower San Joaquin Valley (*8*), the Temple soils were included with the Stockton; and, in the similar

survey of the Middle San Joaquin Valley (*3*), they were included with the Merced. The Temple soils have several characteristics similar to both the Stockton and Merced, but the three series are considered distinct as now defined.

Temple silty clay loam (0- to 1-percent slopes) (Td).—Numerous bodies of this deep soil are scattered throughout the basin area. All of it is free of alkali or only slightly affected. The dark-gray or black silty clay loam surface soil is noncalcareous, friable, and relatively high in organic matter. It has a weak blocky structure and is slightly mottled with rust-brown iron stains. The reaction is nearly neutral or slightly basic.

The upper subsoil, beginning at an average depth of about 10 inches, is a dark gray to black, intermittently calcareous silty clay or clay that breaks to a weak blocky structure when dry. When wet, it is massive and sticky. Numerous well-preserved root holes and insect borings facilitate moisture penetration, and the soil is noticeably streaked with dull-gray and dark-brown mottling. Below this, to a depth of not more than 40 inches, the subsoil is frequently stratified with fine sandy material, usually highly calcareous, that contains soft nodular lime accumulations in addition to lime in a disseminated form. The lower subsoil is olive gray or dark gray and considerably streaked with greenish-gray and dark-brown mottlings. Beneath this layer is the typical substratum of the basin area, a light olive-gray highly calcareous and micaceous sandy clay or sandy clay loam.

The native cover of tules and grasses has practically disappeared from the area, since the soil has been intensively cultivated and irrigated. Fair to better than average yields for the area are obtained from plantings of cotton and small grains, mainly barley. The yields depend on the degree of alkali accumulation. Alfalfa is successfully grown, and the hay produced is of good quality An occasional summer fallowing or dressing of barnyard manure will help maintain consistently good yields. Surface drainage is maintained by frequent drainage ditches. In places slightly affected with salts, the salts are largely in the subsoil beyond the reach of shallow-rooted crops.

Temple silty clay (0- to 1-percent slopes) (Tb).—A small body of this soil is located in the extreme northern part of the area. Surface runoff is very slow. All of the soil contains some alkali, usually a weak concentration.

The surface soil is dark-gray or black noncalcareous silty clay about 9 inches thick. It is friable, blocky in structure, and low in volume-weight. The organic-matter content is high and in places approaches that of a muck soil. Numerous well-preserved root holes and insect borings permeate this layer and increase its porosity. The reaction is neutral.

The upper subsoil is a dark-gray or black intermittently calcareous silty clay, moderately compact and noticeably stained with colloidal material. The silty clay aggregates are blocky when dry, but they are easily crushed under slight pressure. This subsoil layer has an appreciable content of organic matter, but its volume-weight is not quite so low as that of the surface soil. Below this and to a depth of 50 inches or less, the subsoil is very dark grayish-brown highly calcareous clay. In spite of its clay texture, it is friable. The organic-matter content is relatively low, and the soil is highly mottled with

rust-brown iron stains. Below a depth of 50 inches, the material is generally light olive gray and mottled with dull-gray stains. It consists of clay, usually highly calcareous, mixed and often stratified with micaceous fine sandy material. Numerous soft lime blotches and a few hard pellets occur. It resembles the underlying substratum of the Temple and other basin soils.

Temple silty clay is considered to be one of the better agricultural soils of the basin area. Alfalfa does fairly well and barley very well (pl. 4, *B*). Adequate surface drainage is maintained by drainage ditches and pumps, but all of the soil contains some alkali; most of it in weak concentrations, however. The native vegetation of tules and marsh grasses has disappeared, since the land has been drained and intensively farmed.

Temple silty clay, shallow (0- to 1-percent slopes) (Tc).—This soil is an incomplete profile of Temple silty clay in which the black or very dark-gray upper subsoil layer does not occur. A large area is located in and around Tranquillity. Runoff is very slow, and small areas are affected by moderate to strong accumulations of alkali.

The surface soil is an 8-inch layer of very dark-gray, noncalcareous, friable, highly organic silty clay that breaks into a blocky structure. When viewed across a plowed field under certain light conditions, the soil takes on a decided purplish hue.

The surface material is underlain abruptly by a dark olive-gray slightly calcareous, and compact silty clay. It breaks into firm blocky aggregates of irregular size that are faintly stained with colloidal material and contain an appreciable quantity of very small grit and mica flakes. At an average depth of about 30 inches, the silty clay subsoil grades into a light olive-gray highly calcareous sandy clay loam that is gritty and micaceous. The subsoil becomes increasingly sandy in texture and decreasingly calcareous with depth and is noticeably mottled with rust-brown iron stains. The underlying substratum below a depth of 60 inches is similar to that underlying practically all of the basin soils of this area.

Most of this soil is irrigated and under cultivation, and only a remnant of the native cover of tules and swampgrasses remains. Fair to good yields of cotton and small grains, mainly barley, are obtained where the salts are not concentrated too near the shallow rooting zone of these plants. Alfalfa does fairly well but usually needs reseeding at the end of the third or fourth year. Fortunately, nearly 90 percent of the soil is only slightly affected with alkali, and this is usually localized below the root zone of shallow-rooted crops. Adequate surface drainage is maintained by drainage ditches and shallow-well pumps.

Temple clay loam (0- to 1-percent slopes) (Ta).—Small widely scattered bodies of this deep, moderately permeable, nearly level soil are present throughout the basin area. Runoff is very slow, and most of the soil is free of harmful accumulations of alkali.

The average surface layer is black or dark-gray, noncalcareous, friable clay loam about 10 inches thick. It is readily crumbled to a soft granular mass. When wet, it maintains a better tilth than does Temple silty clay loam and is not so readily puddled. There is a gradual change to a black or dark-gray, intermittently calcareous, and slightly more compact subsoil. This friable material can be pene-

trated by roots and water and contains numerous well-preserved worm or insect borings. Dark-brown and gray mottlings are prominent throughout. The deeper subsoil, olive-gray or black and highly mottled with greenish-gray and dark-brown stains, extends to depths not exceeding 50 inches and is more calcareous than is typical of the Temple series. There is an appreciable quantity of segregated lime in addition to the disseminated form. Very often there is a stratification of highly calcareous fine sandy or silty material containing some crystalline gypsum. The substratum is light olive-gray, calcareous, and micaceous sandy clay loam like that underlying most of the basin soils.

Temple clay loam has been intensively cultivated and irrigated for a long time, and most of the native vegetation of tules and grasses has been replaced by a mixture of weeds and other plants. Good yields are obtained from cotton, small grains, and other field crops. Alfalfa also grows well and produces a good quality of hay. An occasional fallowing and treatment of barnyard manure will aid materially in maintaining the fertility of the soil. Adequate surface drainage is provided by ditches spaced at frequent intervals. Most of the soil is free of harmful accumulations of alkali. Low concentrations of alkali occur in the subsoil in a few places.

TRAVER SERIES

The Traver soil is derived from granitic alluvium deposited along the old stream channels in the basin area. It now occupies low isolated ridges elevated a few feet above the surrounding soils. Its characteristics are those of soils with young or weakly developed profiles. It is not eroded, and there has been no recent deposition of fresh alluvium. Because of its stream-ridge position, surface drainage is adequate, but internal drainage is retarded by the slightly compact subsoil. Except in the upper surface layers the organic content is low. In this area, the soil is affected by moderate to strong concentrations of alkali distributed rather uniformly throughout the profile. The native plant cover consists almost entirely of saltgrasses, with which an occasional area of low, salt-tolerant brush is included.

To a depth of about 17 inches, the surface soil is brownish gray, moderately coarse textured, and calcareous. It is friable and easily penetrated by roots and water. There is a gradual transition to a somewhat stratified upper subsoil that is slightly compact and weakly blocky. This layer is light gray, highly calcareous, and in places stained with organic colloidal matter. The lower subsoil, occurring below an average depth of 36 inches, is light brownish gray and only slightly compact, but it often contains thin panlike lenses or nodules of lime carbonate. It is medium-textured and friable and has a massive structure. The underlying substratum composed of light olive-gray, calcareous, sandy clay loam materials is similar to the material under most of the basin soils.

The Traver soil has no particular agricultural value, and in many places the soils immediately adjacent to it also have little agricultural value because of high concentrations of salts. In this area, practically all of the isolated stream ridges occupied by Traver soil are surrounded by dark-colored moderately developed soils of the Merced series.

Traver soil was included mainly with the broadly defined Fresno series in the earlier reconnaissance survey of the Lower San Joaquin Valley (*8*).

Traver fine sandy loam (0- to 3-percent slopes) (Te).—All of this soil contains moderate to strong concentrations of soluble salts. It is not extensive in the area.

The typical surface soil is a brownish-gray, calcareous, micaceous, friable fine sandy loam. This surface layer is usually capped with a 2- to 3-inch layer of organic soil that contains a decaying mass of small roots.

The upper subsoil, beginning at a depth of about 16 inches, is light gray, highly calcareous, and slightly compact. It is usually a fine sandy loam that contains an appreciable quantity of mica and black gritty material. Downward from a depth of 36 or more inches, the subsoil is a light brownish-gray slightly compact fine sandy loam that contains thin panlike lenses or nodules of lime in many places. The underlying material, usually encountered at depths below 60 inches, is typical of that occurring in the basin area. It is composed of light olive-gray highly calcareous, gritty, micaceous, mottled sandy materials.

None of this soil is cultivated, because it has a high alkali content and occurs in very small bodies on the low ridges within the valley basin. It is used as a saltgrass pasture during the summer months.

WILLOWS SERIES

Willows soil has developed from alluvium primarily of sedimentary rock origin, but in places some alluvial material from granitic rock is included. The alluvial material has been deposited in nearly level basin areas, and there has been no recent deposition or erosion. Surface and internal drainage are both very slow, and the water table is frequently high. The salt content is usually high, but it is confined to the subsoil layers. Native vegetation was mainly saltgrass and saltbush and in a few places, tules and sedges.

Willows surface soil is intermittently calcareous, dark grayish brown or brownish gray, and fine textured. It develops large cracks when dry, and hard blocks are formed. When wet, it is dense and extremely sticky. Most of the plant roots and saltgrass stolons occur in the surface layer where the profile is slightly more penetrable.

The subsoil, beginning at an average depth of about 20 inches, is dense, grayish brown, and somewhat mottled with rust-brown stains. It contains variable amounts of lime and gypsum. Roots rarely penetrate to this layer. The deeper subsoil is dense and often light brown. It contains appreciable amounts of segregated lime and gypsum. The underlying parent material does not differ greatly from the lower subsoil in color and texture, but it is usually below the water table. There is some crystalline gypsum, which is usually closely associated with segregated lime carbonate.

The Willows soil in this area is associated with the grayish-brown Lethent soil that occupies the older parts of the broad alluvial fans. It is also associated with the recent dark brownish-gray Oxalis soil, which is located on the very slowly drained outer fringe of the Panoche fan. Willows soils occur more extensively in the Los Banos Area (*1*)

to the north. In that area, they were included mainly with Capay soils when the earlier reconnaissance survey of the Lower San Joaquin Valley (*8*) was made.

Willows clay (0- to 1-percent slopes) (WA).—Along the northern boundary of the area there is one body of this nearly level soil, all of which is moderately affected by alkali.

The surface soil of Willows clay, 6 to 18 inches deep, is a dark grayish-brown or brownish-gray intermittently calcareous clay. It develops an adobe structure on drying, and shrinks and cracks into very hard irregular blocks, often as much as 12 inches across. When the soil is wet it swells and becomes massive and sticky. There are many grass roots and saltgrass stolons throughout this layer.

The subsoil, which extends to depths of 40 or more inches, is a highly mottled grayish-brown clay that is moderately compact. It contains an appreciable quantity of segregated lime and crystalline gypsum. Surface cracks extending into the upper part of this horizon give a firm, blocky structure. Below a depth of 50 inches, the underlying light-brown substratum continues for a considerable distance. This material is highly calcareous and gypsiferous, and there is some rust-brown or gray mottling.

In areas where the soil has been cleared and leveled and drainage ditches have been constructed, rice and cotton are grown. Rice gives fair yields because the moderate amounts of alkali present are largely confined to the subsoils below the rooting zone. Frequent drainage ditches are successful in maintaining adequate surface drainage.

RELATIVE SUITABILITY OF SOILS FOR AGRICULTURE

The aim of efficient land use and good soil management is the production of an adequate income over a period of years and the concurrent maintenance of the productivity of the soil. This objective requires use of the land for the purpose or purposes to which it is best suited, the adoption of suitable types of farming, the growing of the crops that are best adapted, and the use of methods of soil management—including irrigation, crop rotation, tillage practices, and applications of manures and fertilizers—that will maintain or build up the fertility of the soil and minimize erosion. To practice good soil management, the farmer must know the good points and deficiencies of his soil and utilize it in a manner that will make use of the former and overcome the latter.

Because of the low annual rainfall and rainless summers in the Mendota Area, all crops except a relatively small acreage of dry-farmed grains are grown on irrigated land. Irrigation water is available only for the lower lying land where slopes seldom exceed 2 or 3 percent. Aside from water supply, the principal modifying or limiting factors in determining the suitability of a soil for the various crops are the depth, texture, and structure of surface soil and subsoil, the drainage, and the accumulation of salts. Erosion is of little importance in the Mendota Area on the cultivated soils when they are properly irrigated, but it is of considerable importance on the upland soils, where intensive grazing of sheep has resulted in moderate to severe erosion in a number of places. Other factors that influence

productivity of a soil to some degree, especially under irrigation, include fertility, the content of organic matter, soil reaction, and the lime content.

In this report, soil management for specific crops is given in the section on Agriculture under the subsection, Crops. Irrigation practices for specific crops are also discussed. In the section on Alkali, methods of management for alkali soils are described. For information on the important characteristics that largely govern the use of the soils in the area, the supplement to the soil map should be consulted. In relative terms, it describes the slope range, profile, depth, permeability, surface runoff, occurrence of alkali or high water table, available water-holding capacity, erodibility, natural fertility, workability, and present use of each of the soils in the Mendota Area. A more detailed discussion of particular soils and their agricultural uses and relationships is given in the body of the report in the section on Soil Series, Types, and Phases.

The soils of the area are arranged in alphabetic order and rated according to the Storie index (*12*, *15*) [13] in table 6. This index expresses numerically the relative degree of suitability, or value, of a soil for general intensive agriculture. The rating is based on soil characteristics only and is obtained by evaluating such factors as depth, texture of the surface soil and density of subsoil, drainage, alkali content, and relief. Other physical land factors, such as availability of water for irrigation, climate, and distance from markets, that might determine the desirability of growing certain plants in a given locality, are not considered. Therefore, in itself, the index cannot be considered as an index of land evaluation.

Four general factors are considered in the index rating. These factors are: A, the character of the soil profile and soil depth; B, the texture of the surface soil; C, slope; and X, other factors such as drainage, alkali, and erosion. Each of the four general factors is evaluated on the basis of 100 percent. A rating of 100 percent expresses the most favorable or ideal condition, and lower percentage ratings are given for conditions that are less favorable to plant growth. The index rating for a soil is obtained by multiplying the four factors, A, B, C, and X; thus any one factor may dominate or control the final rating. As an example, a soil may have an excellent profile condition giving a rating of 100 percent for factor A, excellent surface soil conditions giving 100 percent for factor B, a smooth nearly level surface giving 100 percent for factor C, but a high accumulation of salts or alkali that would justify a rating of 10 percent for factor X. Multiplying these four ratings gives an index rating of 10 for this soil. The high accumulation of salts dominates the quality of the soil, renders it unproductive for crops in its present state, and justifies the low index rating of 10.

According to index rating, the soils are placed in six classes or grades. Class 1 soils are excellent, well suited to general intensive agriculture, and range in index rating from 80 to 100; class 2 soils are good, relatively well suited to agriculture, and range in rating from

[13] This system of rating soils was further revised in 1944 by R. Earl Storie in a lithoprint of the California Agricultural Experiment Station titled Revision of the Soil-rating Chart.

TABLE 6.—*Index rating for soils of the Mendota Area, Calif.*

[Letter preceding the word "alkali": S=slight alkali; M=moderate alkali; MA=moderately strong alkali; and A=strong alkali.]

Soil	Index rating factors				Index rating	Class and sub-class
	A (Soil profile and depth)	B (Surface texture)	C (Slope)	X (Other characteristics)		
	Percent	*Percent*	*Percent*	*Percent*		
Columbia fine sandy loam	100	100	100	[1] 90	90	1B
S alkali	100	100	100	[2] 72	72	2C
Columbia loam	100	100	100	[1] 90	90	1B
S alkali	100	100	100	[2] 72	72	2C
Columbia soils, undifferentiated					[3] 20–80	3A
S alkali					[3] 15–65	3A
Kettleman fine sandy loam:						
Hilly, eroded	40	100	75	[4] 75	23	4B
Steep, eroded	40	100	30	[4] 75	9	6B
Undulating	50	100	95	100	48	3B
Kettleman gravelly clay loam:						
Hilly, eroded	40	70	75	[4] 75	16	5B
Steep, eroded	40	70	30	[4] 75	6	6B
Undulating	50	70	95	100	33	4B
Kettleman silty clay loam:						
Hilly, eroded	60	90	75	[4] 75	30	4B
Rolling, eroded	60	90	85	[4] 75	34	4B
Steep, eroded	50	90	30	[4] 70	9	6B
Undulating	60	90	95	100	51	3B
Kettleman stony clay, very gently sloping	80	50	100	100	40	3B
Lethent silty clay:						
M alkali	80	70	100	[5] 40	22	4A
MA alkali	80	70	100	[6] 24	13	5A
A alkali	80	70	100	[7] 8	4	6A
Levis silty clay:						
MA alkali	95	70	100	[8] 30	20	4A
A alkali	95	70	100	[9] 12	8	6A
Los Banos clay loam:						
Steep	85	70	65	100	39	4B
Undulating and rolling	85	70	85	100	51	3B
Lost Hills clay loam:						
Gently sloping	85	85	95	[10] 90	62	2B
S alkali	85	85	95	[11] 72	49	3B
Very gently sloping	85	85	100	[10] 90	65	2B
S alkali	85	85	100	[11] 72	52	3A
M alkali	85	85	100	[12] 36	26	4A
Lost Hills gravelly clay loam, sloping	85	60	85	[10] 90	39	4B A
Lost Hills loam, very gently sloping	85	100	100	[10] 90	76	2B
M alkali	85	100	100	[12] 36	31	4A
Merced clay (adobe):						
S alkali	70	60	100	[2] 64	27	4A
M alkali	70	60	100	[5] 36	15	5A
MA alkali	70	60	100	[6] 24	10	5A
A alkali	70	60	100	[7] 8	3	6A

See footnotes at end of table.

TABLE 6.—*Index rating for soils of the Mendota Area, Calif.*—Con.

[Letter preceding the word "alkali": S=slight alkali; M=moderate alkali; MA=moderately strong alkali; and A=strong alkali.]

Soil	Index rating factors				Index rating	Class and subclass
	A (Soil profile and depth)	B (Surface texture)	C (Slope)	X (Other characteristics)		
	Percent	*Percent*	*Percent*	*Percent*		
Merced clay (adobe), shallow, over Traver soil material:						
S alkali	70	60	100	[2] 72	30	4A
M alkali	70	60	100	[5] 36	15	5A
A alkali	70	60	100	[7] 8	3	6A
Merced clay (adobe), shallow, over Willows soil material:						A
S alkali	70	60	100	[2] 64	27	4A
M alkali	70	60	100	[5] 36	15	5A
A alkali	70	60	100	[7] 8	3	6A
Ortigalita clay loam:						
Gently sloping	80	85	95	[10] 90	58	3B
Very gently sloping	80	85	100	[10] 90	61	2B
Oxalis silty clay:						
S alkali	95	70	100	[2] 81	54	3A
M alkali	95	70	100	[5] 45	30	4A
MA alkali	95	70	100	[6] 27	18	5A
A alkali	95	70	100	[7] 14	9	6A
Panhill clay loam:						
Gently sloping	95	85	95	100	77	2B
Very gently sloping	95	85	100	100	81	1A
S alkali	95	85	100	[13] 90	73	1A
Panhill silt loam:						
Gently sloping	100	100	95	100	95	1A
Very gently sloping	100	100	100	100	100	1A
S alkali	100	100	100	[13] 90	90	1B
Panoche clay loam	100	85	100	100	85	1A
S alkali	100	85	100	[13] 90	77	2C
M alkali	100	85	100	[14] 60	51	3A
Panoche clay loam, shallow, over Panhill soil material	95	85	100	100	81	1A
Panoche fine sandy loam	[15] 95	100	100	100	95	1A
S alkali	[15] 95	100	100	[13] 90	86	1B
Panoche gravelly loam	[16] 95	70	100	100	67	2A
Panoche loam	100	100	100	100	100	1A
S alkali	100	100	100	[13] 90	90	1B
Panoche loamy fine sand	[15] 80	90	100	100	72	2A
Panoche silt loam, shallow, over Lost Hills soil material.	85	100	100	[10] 95	81	1A
Panoche silty clay	100	70	100	100	70	2B
S alkali	100	70	100	[13] 90	63	2C
M alkali	100	70	100	[14] 60	42	3A
Panoche silty clay loam	100	90	100	100	90	1A
S alkali	100	90	100	[13] 90	81	1B

See footnotes at end of table.

TABLE 6.—*Index rating for soils of the Mendota Area, Calif.*—Con.

[Letter preceding the word "alkali": S=slight alkali; M=moderate alkali; MA=moderately strong alkali; and A=strong alkali.]

Soil	Index rating factors: A (Soil profile and depth)	B (Surface texture)	C (Slope)	X (Other characteristics)	Index rating	Class and subclass
	Percent	*Percent*	*Percent*	*Percent*		
Panoche silty clay loam, shallow, over Lost Hills soil material	85	90	100	[10] 95	73	2B
S alkali	85	90	100	[11] 76	58	3A
M alkali	85	90	100	[12] 38	29	4A
Riverwash					[3] 2	6B
Rossi clay loam (A alkali)	60	85	100	[7] 8	4	6A
Rough broken land					[3] 5	6B
Temple clay loam	95	85	100	[1] 80	65	2C
S alkali	95	85	100	[2] 64	52	3A
Temple silty clay:						
S alkali	95	70	100	[2] 64	43	3A
M alkali	95	70	100	[5] 32	21	4A
Temple silty clay, shallow:						
S alkali	90	70	100	[2] 64	40	3A
M alkali	90	70	100	[5] 32	20	4A
A alkali	90	70	100	[7] 8	5	6A
Temple silty clay loam	95	90	100	[1] 80	68	2C
S alkali	95	90	100	[2] 64	55	3A
Traver fine sandy loam:						
M alkali	95	100	100	[5] 24	23	4A
A alkali	95	100	100	[7] 8	8	6A
Willows clay (M alkali)	85	50	100	[5] 24	10	5A

[1] Imperfect drainage.
[2] Imperfect drainage and slight alkali.
[3] Estimated range; not obtained through use of factors.
[4] Moderately to severely eroded.
[5] Imperfect drainage and moderate alkali.
[6] Imperfect drainage and moderately strong alkali.
[7] Imperfect drainage and strong alkali.
[8] Moderately strong alkali.
[9] Strong alkali.
[10] Low hummocky microrelief.
[11] Low hummocky microrelief and slight alkali.
[12] Low hummocky microrelief and moderate alkali.
[13] Slight alkali.
[14] Moderate alkali.
[15] Stratified profile.

60 to 80; class 3 soils are only fairly well suited and range in rating from 40 to 60; class 4 soils are poorly suited and range in rating from 20 to 40; class 5 soils are very poorly suited and range in rating from 10 to 20; and class 6 consists of nonagricultural soils and land types that have ratings of less than 10.

Table 7 groups the soils of the Mendota Area according to class and describes in relative terms—very good, good, fair, poor, and very poor—the suitability of each soil for the principal crops of the area. The soil classes are further divided into subclasses on the basis of physical factors, such as poor drainage, shallowness of profile, and alkali accumulation, that limit their value for general intensive agriculture.

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TABLE 7.—*Relative suitability for principal crops of soils of the Mend*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb slight; M=moderate; MA=moderately strong; and A=strong

CLASS 1.—SOILS WELL SUITED TO GENERAL INTENSIVE AGRICULT

Soils and subclasses [1]	Cotton	Alfalfa	Flaxseed	I
Subclass 1A:				
Panhill clay loam, very gently sloping	Very good	Very good	Very good	Go
Panhill silt loam, very gently sloping	do	do	do	Ve
Panhill silt loam, gently sloping	Good	do	do	c
Panoche silty clay loam	Very good	do	do	Go
Panoche silt loam, shallow, over Lost Hills soil material.	Good	Good	do	Ve
Panoche loam	Very good	Very good	do	c
Panoche fine sandy loam	Good	do	Good	c
Panoche clay loam	Very good	do	Very good	Go
Panoche clay loam, shallow, over Panhill soil material.	do	do	do	c
Subclass 1B:				
Columbia fine sandy loam	Good	do	Good	Ve
Columbia loam	do	do	do	c
Panhill silt loam, very gently sloping (S alkali)	do	Good	do	Go
Panoche silty clay loam (S alkali)	do	do	Very good	c
Panoche loam (S alkali)	do	do	Good	c
Panoche fine sandy loam (S alkali)	do	do	do	c

Class 2.—Soils Moderately Suited to General Intensive Agric

Subclass 2A:				
Panoche gravelly loam	Good	Good	Fair	Go
Panoche loamy fine sand	do	do	do	
Subclass 2B:				
Lost Hills clay loam, very gently sloping	Fair	do	Good	Fa
Lost Hills clay loam, gently sloping	do	do	do	
Lost Hills loam, very gently sloping	Good	do	do	Go
Ortigalita clay loam, very gently sloping	Fair	Fair	do	Fa
Panhill clay loam, gently sloping	Good	Good	Very good	Go
Panoche silty clay	do	do	do	Fa
Panoche silty clay loam, shallow, over Lost Hills soil material.	do	do	do	Go
Subclass 2C:				
Columbia fine sandy loam (S alkali)	do	do	Good	
Columbia loam (S alkali)	do	do	do	
Panhill clay loam, very gently sloping (S alkali)	do	do	Very good	
Panoche silty clay (S alkali)	do	do	Good	Fa
Panoche clay loam (S alkali)	do	do	Very good	Go
Temple silty clay loam	do	do	Good	Fa
Temple clay loam	do	do	do	

See footnotes at end of table.

TABLE 7.—*Relative suitability for principal crops of soils of the Mendota Ar*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb slight; M=moderate; MA=moderately strong; and A=strong

CLASS 3.—SOILS FAIRLY WELL SUITED TO GENERAL INTENSIVE AGRI

Soils and subclasses [1]	Cotton	Alfalfa	Flaxseed	
Subclass 3A:				
Columbia soils, undifferentiated	(2)	(2)	(2)	
Columbia soils, undifferentiated (S alkali)	(2)	(2)	(2)	
Lost Hills clay loam, very gently sloping (S alkali).	Fair	Fair	Fair	Fa
Oxalis silty clay (S alkali)	Good	do	Good	
Panoche silty clay (M alkali)	Fair	do	Fair	Po
Panoche silty clay loam, shallow, over Lost Hills soil material (S alkali).	Good	do	Good	Fa
Panoche clay loam (M alkali)	Fair	do	Fair	
Temple silty clay loam (S alkali)	Good	do	Good	
Temple silty clay (S alkali)	Fair	do	do	Po
Temple silty clay, shallow (S alkali)	do	do	do	
Temple clay loam (S alkali)	Good	do	do	Fa
Subclass 3B:				
Kettleman silty clay loam, undulating	Poor	do	Fair	
Kettleman fine sandy loam, undulating	do	do	Poor	
Kettleman stony clay, very gently sloping	do	Poor	do	Po
Los Banos clay loam, undulating and rolling	do	Fair	do	Fa
Lost Hills clay loam, gently sloping (S alkali)	Fair	do	Fair	Po
Ortigalita clay loam, gently sloping	do	do	do	Fa

CLASSES 4 AND 5.—SOILS POORLY AND VERY POORLY SUITED TO GENERAL INTE

Subclasses 4A and 5A:				
Lethent silty clay (M alkali)	Poor	Poor	Poor	Po
Lethent silty clay (MA alkali)	Very poor	Very poor	do	---
Levis silty clay (MA alkali)	Poor	Poor	do	---
Lost Hills clay loam, very gently sloping (M alkali).	do	do	do	---
Lost Hills loam, very gently sloping (M alkali)	do	do	Fair	---
Merced clay (adobe) (S alkali)	Fair	do	do	---
Merced clay (adobe) (M alkali)	Poor	do	Poor	---
Merced clay (adobe) (MA alkali)	Very poor	Very poor	Very poor	---
Merced clay (adobe), shallow, over Traver soil material (S alkali).	Fair	Fair	Fair	---
Merced clay (adobe), shallow, over Traver soil material (M alkali).	Poor	Poor	Poor	---
Merced clay (adobe), shallow, over Willows soil material (S alkali).	Fair	do	Fair	---
Merced clay (adobe), shallow, over Willows soil material (M alkali).	Very poor	Very poor	Poor	---
Oxalis silty clay (M alkali)	Fair	Poor	Fair	---
Oxalis silty clay (MA alkali)	Poor	do	Poor	---
Panoche silty clay loam, shallow, over Lost Hills soil material (M alkali).	Fair	do	Fair	---
Temple silty clay (M alkali)	Poor	do	Poor	---
Temple silty clay, shallow (M alkali)	do	do	do	---
Traver fine sandy loam (M alkali)	do	do	do	---
Willows clay (M alkali)	do	Very poor	do	---
Subclasses 4B and 5B:				
Kettleman silty clay loam, hilly, eroded	Very poor	do	Very poor	Ve
Kettleman silty clay loam, rolling, eroded	Poor	Poor	do	---
Kettleman silty clay loam, steep, eroded	Very poor	Very poor	do	---
Kettleman fine sandy loam, hilly, eroded	do	do	do	---
Kettleman gravelly clay loam, hilly, eroded	do	do	do	---
Kettleman gravelly clay loam, undulating	Poor	Fair	Poor	Po
Los Banos clay loam, steep	Very poor	Poor	Very poor	Ve
Lost Hills gravelly clay loam, sloping	Poor	Fair	Poor	Po

See footnotes at end of table.

TABLE 7.—*Relative suitability for principal crops of soils of the Mendota Ar*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb
slight; M=moderate; MA=moderately strong; and A=strong

CLASS 6.—NONAGRICULTURAL SOILS AND LAND TYPES

Soils and subclasses [1]	Cotton	Alfalfa	Flaxseed
Subclass 6A:			
Lethent silty clay (A alkali)	Very poor	Very poor	Very poor
Levis silty clay (A alkali)	do	do	do
Merced clay (adobe) (A alkali)	do	do	do
Merced clay (adobe), shallow, over Traver soil material (A alkali).	do	do	do
Merced clay (adobe), shallow, over Willows soil material (A alkali).	do	do	do
Oxalis silty clay (A alkali)	do	do	do
Rossi clay loam (A alkali)	do	do	do
Temple silty clay, shallow (A alkali)	do	do	do
Traver fine sandy loam (A alkali)	do	do	do
Subclass 6B:			
Kettleman fine sandy loam, steep, eroded	do	do	do
Kettleman gravelly clay loam, steep, eroded	do	do	do
Riverwash	do	do	do
Rough broken land	do	do	do

TABLE 7.—*Relative suitability for principal crops of soils of the Mendota A*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb
slight; M=moderate; MA=moderately strong; and A=stron

CLASS 1.—SOILS WELL SUITED TO GENERAL INTENSIVE AGRICULT

Soils and subclasses [1]	Wheat		Barley		
	Irrigated	Nonirrigated	Irrigated	Nonirrigated	
Subclass 1A:					
Panhill clay loam, very gently sloping.	Very good	Poor	Very good	Poor	Go
Panhill silt loam, very gently sloping.	do	do	do	do	
Panhill silt loam, gently sloping	do	do	do	do	Po
Panoche silty clay loam	do	do	do	do	Go
Panoche silt loam, shallow, over Lost Hills soil material.	do	do	do	do	
Panoche loam	do	do	do	do	Fa
Panoche fine sandy loam	Good	do	Good	do	Po
Panoche clay loam	Very good	do	Very good	do	Go
Panoche clay loam, shallow, over Panhill soil material.	do	do	do	do	
Subclass 1B:					
Columbia fine sandy loam	do	Fair	do	Fair	Po
Columbia loam	do	do	do	do	Fa
Panhill silt loam, very gently sloping (S alkali).	do	Poor	do	Poor	Go
Panoche silty clay loam (S alkali).	do	do	do	do	
Panoche loam (S alkali)	do	do	do	do	Fa
Panoche fine sandy loam (S alkali).	Good	do	do	do	Po

See footnotes at end of table.

TABLE 7.—*Relative suitability for principal crops of soils of the Mendota A*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb
slight; M=moderate; MA=moderately strong; and A=strong

CLASS 2.—SOILS MODERATELY SUITED TO GENERAL INTENSIVE AGRIC

Soils and subclasses [1]	Wheat		Barley		
	Irrigated	Nonirrigated	Irrigated	Nonirrigated	
Subclass 2A:					
Panoche gravelly loam	Good	Poor	Good	Poor	Po
Panoche loamy fine sand	do	do	do	do	
Subclass 2B:					
Lost Hills clay loam, very gently sloping.	Very good	do	Very good	do	Go
Lost Hills clay loam, gently sloping.	Good	do	Good	do	Po
Lost Hills loam, very gently sloping.	Very good	do	Very good	do	Fa
Ortigalita clay loam, very gently sloping.	Good	do	Good	do	Po
Panhill clay loam, gently sloping	Very good	do	Very good	do	
Panoche silty clay	do	do	do	do	Go
Panoche silty clay loam, shallow, over Lost Hills soil material.	do	do	do	do	
Subclass 2C:					
Columbia fine sandy loam (S alkali).	do	Fair	do	Fair	Po
Columbia loam (S alkali)	do	do	do	do	Fa
Panhill clay loam, very gently sloping (S alkali).	do	Poor	do	Poor	Go
Panoche silty clay (S alkali)	do	do	do	do	
Panoche clay loam (S alkali)	do	do	do	do	
Temple silty clay loam	do	Good	do	Good	
Temple clay loam	do	do	do	do	

CLASS 3.—SOILS FAIRLY WELL SUITED TO GENERAL INTENSIVE AGRI

Subclass 3A:					
Columbia soils, undifferentiated	(2)	(2)	(2)	(2)	
Columbia soils, undifferentiated (S alkali).	(2)	(2)	(2)	(2)	
Lost Hills clay loam, very gently sloping (S alkali).	Good	Poor	Good	Poor	Go
Oxalis silty clay (S alkali)	Very good	do	Very good	do	---
Panoche silty clay (M alkali)	Good	do	Good	do	---
Panoche silty clay loam, shallow, over Lost Hills soil material (S alkali).	Very good	do	Very good	do	---
Panoche clay loam (M alkali)	Good	do	Good	do	---
Temple silty clay loam (S alkali)	Very good	Good	Very good	Good	---
Temple silty clay (S alkali)	do	do	do	do	---
Temple silty clay, shallow (S alkali).	Good	Fair	Good	Fair	---
Temple clay loam (S alkali)	Very good	Good	Very good	Good	---
Subclass 3B:					
Kettleman silty clay loam, undulating.	Fair	Poor	Fair	Poor	Ve
Kettleman fine sandy loam, undulating.	do	do	do	do	---
Kettleman stony clay, very gently sloping.	Poor	do	Poor	do	Po
Los Banos clay loam, undulating and rolling.	Fair	do	Fair	do	Ve
Lost Hills clay loam, gently sloping (S alkali).	Good	do	Good	do	Po
Ortigalita clay loam, gently sloping.	do	do	do	do	---

See footnotes at end of table.

TABLE 7.—*Relative suitability for principal crops of soils of the Mendota Ar*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb slight; M = moderate; MA = moderately strong; and A = strong

CLASSES 4 AND 5.—SOILS POORLY AND VERY POORLY SUITED TO GENERAL INT

Soils and subclasses [1]	Wheat		Barley		
	Irrigated	Nonirrigated	Irrigated	Nonirrigated	
Subclasses 4A and 5A:					
Lethent silty clay (M alkali)	Fair	Poor	Fair	Poor	Fa
Lethent silty clay (MA alkali)	Poor	Very poor	Poor	Very poor	Go
Levis silty clay (MA alkali)	do	do	do	do	
Lost Hills clay loam, very gently sloping (M alkali).	Fair	Poor	Fair	Poor	Fa
Lost Hills loam, very gently sloping (M alkali).	Poor	do	do	do	
Merced clay (adobe) (S alkali)	Good	do	Good	do	Go
Merced clay (adobe) (M alkali)	Fair	do	Fair	do	
Merced clay (adobe) (MA alkali)	Poor	do	Poor	do	
Merced clay (adobe), shallow, over Traver soil material (S alkali).	Good	Fair	Good	Fair	
Merced clay (adobe), shallow, over Traver soil material (M alkali).	Fair	Poor	Fair	Poor	
Merced clay (adobe), shallow, over Willows soil material (S alkali).	Good	do	Good	do	
Merced clay (adobe), shallow, over Willows soil material (M alkali).	Fair	do	Fair	do	
Oxalis silty clay (M alkali)	do	do	do	do	

Oxalis silty clay (MA alkali)	Poor	Very poor	Poor	Very poor	
Panoche silty clay loam, shallow, over Lost Hills soil material (M alkali).	Fair	Poor	Fair	Poor	
Temple silty clay (M alkali)	do	do	do	do	
Temple silty clay, shallow (M alkali).	do	do	do	do	
Traver fine sandy loam (M alkali).	do	do	do	do	Po
Willows clay (M alkali)	Poor	Very poor	Poor	Very poor	Go
Subclasses 4B and 5B:					
Kettleman silty clay loam, hilly, eroded.	do	Poor	do	Poor	Ve
Kettleman silty clay loam, rolling, eroded.	do	do	do	do	
Kettleman silty clay loam, steep, eroded.	Very poor	Very poor	Very poor	Very poor	
Kettleman fine sandy loam, hilly, eroded.	Poor	Poor	Poor	Poor	
Kettleman gravelly clay loam, hilly, eroded.	do	do	do	do	
Kettleman gravelly clay loam, undulating.	Fair	do	Fair	do	
Los Banos clay loam, steep	Poor	do	Poor	do	
Lost Hills gravelly clay loam, sloping.	do	do	do	do	

See footnotes at end of table.

TABLE 7.—*Relative suitability for principal crops of soils of the Mendota A*

[All determinations of suitability are for irrigated crops unless otherwise specified. Letter symb
slight; M=moderate; MA=moderately strong; and A=strong

CLASS 6.—NONAGRICULTURAL SOILS AND LAND TYPES

Soils and subclasses [1]	Wheat		Barley		
	Irrigated	Nonirrigated	Irrigated	Nonirrigated	
Subclass 6A:					
Lethent silty clay (A alkali)	Very poor	Very poor	Very poor	Very poor	Po
Levis silty clay (A alkali)	do	do	do	do	[illegible]
Merced clay (adobe) (A alkali)	do	do	do	do	[illegible]
Merced clay (adobe), shallow, over Traver soil material (A alkali).	do	do	do	do	[illegible]
Merced clay (adobe), shallow, over Willows soil material (A alkali).	do	do	do	do	[illegible]
Oxalis silty clay (A alkali)	do	do	do	do	[illegible]
Rossi clay loam (A alkali)	do	do	do	do	[illegible]
Temple silty clay, shallow (A alkali).	do	do	do	do	[illegible]
Traver fine sandy loam (A alkali)	do	do	do	do	[illegible]
Subclass 6B:					
Kettleman fine sandy loam, steep, eroded.	do	do	do	do	Ve
Kettleman gravelly clay loam, steep, eroded.	do	do	do	do	[illegible]
Riverwash	do	do	do	do	[illegible]
Rough broken land	do	do	do	do	[illegible]

[1] Classes are divided into subclasses on basis of physical limitations to general intensive agri
drainage.

[2] Variable suitability for a specific crop; subject to overflow.

The following is a brief general description of the soil classes and subclasses of the Mendota Area:

Class 1.—Well suited to general intensive agriculture. Soils are easily worked; productivity is relatively easy to maintain; irrigation can be carried out simply and efficiently; and no special practices in erosion control are required.

Subclass 1A.—No significant limitation to production of most of the crops ordinarily grown in the area.

Subclass 1B.—Nearly as well suited to production of many crops as soils in subclass 1A. Care in management is required to prevent an increase in the concentration of alkali. Productivity can be increased by improvement in drainage and by alkali reclamation.

Class 2.—Moderately well suited to general intensive agriculture. Irrigation can be carried out rather simply and efficiently. No special practices in erosion control are required. Range in crops and crop yields is somewhat less than for class 1 soils.

Subclass 2A.—Well-drained rather coarse-textured soils, fairly rapid permeability, but rather low in available moisture-holding capacity. In irrigation, some difficulty is experienced in maintaining proper moisture content.

Subclass 2B.—Well-drained, fine-textured soils of rather slow permeability but fairly high in available water-holding capacity and soils with moderately compact subsoils. Soils are moderately well suited to most field and truck crops.

Subclass 2C.—Imperfectly drained soils or soils slightly affected with soluble salts (alkali). Productivity may be increased for some soils through alkali reclamation, although reclamation is somewhat more difficult than on subclass 1B soils.

Class 3.—Fairly well suited to general intensive agriculture. Range of crops and crop yields is less than for soils in class 2. Productivity is more difficult to improve.

Subclass 3A.—Imperfectly and poorly drained soils and soils affected by some accumulation of alkali. Soils are fairly well suited to irrigated pasture. Natural pasture is generally fairly good. Improvement of productivity is feasible in most places.

Subclass 3B.—Deep to moderately shallow soils that can be irrigated if special practices are employed. Soils are generally suited to irrigated pasture, but a water supply for irrigation has not been developed. Erosion control is necessary in most places if the soils are cultivated.

Classes 4 and 5.—Poorly or very poorly suited to general intensive agriculture. The range of crops is narrow and crop yields are low. The land is generally of marginal character.

Subclasses 4A and 5A.—Imperfectly or poorly drained soils, for the most part fine textured and difficult to work. They contain slight to moderately strong concentrations of alkali but are fairly well suited to irrigated pasture of special seed mixture. Natural pasture is fair to good. Alkali reclamation is difficult.

Subclasses 4B and 5B.—Sloping to hilly soils that can be irrigated only by special practices and soils with gravelly

surfaces. For long-term use, soils are best suited to range pasture. Management to prevent overstocking of pasture and consequent erosion is necessary in most places. Soils are not cultivated, and the possibility of development of a water supply for irrigation is remote.

Class 6.—Nonagricultural soils and miscellaneous land types.

Subclass 6A.—Imperfectly or poorly drained soils that contain strong concentrations of alkali.

Subclass 6B.—Steep eroded soils of shallow profile and nonagricultural miscellaneous land types.

In arriving at an expression of the suitability of a soil to a particular crop, yield is a major factor, but it is not the only one considered. Suitability is evaluated by the following: (1) The climatic and soil requirements of the crop; (2) the probable yield and quality of the crop under the management practices ordinarily used in the area; (3) the feasibility of irrigation if the crop is one that is usually irrigated; and (4) the probable productive life if the crop is a perennial.

Estimated yields for each of the principal crops, according to the five categories of suitability used in table 7, are given in table 8. In these estimates it is assumed that methods of management are those customarily employed in the area.

A crop should not be attempted on a soil if that soil is designated as poorly suited to the crop. Though such a crop might be somewhat successful under very special management, or as a noncommercial home-garden crop, commercial production is generally not feasible. If a crop is grown under common management practices on a soil of fair suitability, the yield should approximate the present average yield for the area. The success of such an enterprise is determined largely by the price received for the crop and by the skill in management. The production of a crop on soils of good or very good suitability for that crop should be successful, assuming normal prices and practices of crop and farm management ordinarily used in the area.

ALKALI

The term "alkali" is used in its locally popular sense in this report, and refers principally to the accumulation of soluble salts in a soil to an extent that may injuriously affect the growth of crops. In this area, the so-called "white alkali" is by far the dominant kind; it consists mainly of sodium chloride (common salt) and sodium sulfate (Glauber's salt) and is almost always associated with high concentrations of gypsum (calcium sulfate). Of the soluble salts or alkali present, sodium chloride is the most toxic, but sodium sulfate is most common. The white-alkali salts common in the Mendota Area are less toxic than sodium carbonate or "black alkali."

The type of alkali, together with the fact that it is concentrated mainly in the subsoils, explains why shallow-rooted crops suffer somewhat less injury in this area than they do in many other parts of the valley that have the same grade or degree of accumulation of salts. Also, the relatively large quantities of gypsum in the soils aid water penetration and apparently decrease the toxicity of the salts. Nonetheless, high salt concentrations in the subsoils do limit the production of deep-rooted crops. The salts tend to rise and accumulate in the root zones of the surface soils if adequate drainage is not maintained.

TABLE 8.—*Estimated range in average yields* [1] *per acre, according to five categori*
Mendota Area, Calif.

Crop	Unit of measure
Cotton (irrigated)	100 lb. of lint
Alfalfa (irrigated)	Tons of hay
Flaxseed (irrigated)	110-lb. (2-bushel) sacks
Cantaloups (irrigated)	Tons (about 33 crates a ton)
Carrots (irrigated)	Tons (with tops) (about 24 crates a ton)
Tomatoes (irrigated)	Tons
Grain sorghums (irrigated)	110-lb. (2-bushel) sacks
Wheat:	
Irrigated	120-lb. (2-bushel) sacks
Nonirrigated	do
Barley:	
Irrigated	100-lb. (2-bushel) sacks
Nonirrigated	do
Rice (irrigated)	90-lb. (2-bushel) sacks
Pasture (seeded and irrigated)[4]	Cow-acre-days [5]
Pasture range (nonirrigated)[6]	do

[1] It is assumed that all estimated yields are for crops grown under the methods of management commonly used in the area.

[2] Crop suitability terms—Very good, Good, Fair, Poor, and Very poor—correspond to those used in table 7, and are explained in the text, pp. 62 to 65, inclusive.

[3] Very low or no yields of commercial importance.

[4] Pasture in which Ladino clover is the main constituent.

[5] The term cow-acre-days
grazing value of pastures or
number of animal units carrie
days that animals can be gr
animal unit is a mature cow,

[6] Range pasture consists of
or mountain areas. In the M
natural forage of the valley f

Most of the alluvial soils of the Mendota Area are derived from the uplands, a considerable part of which consists of highly calcareous and gypsiferous, softly consolidated sandstones and shales. These sandstones and shales have a relatively high inherent content of soluble salts, and it is not surprising that the alluvial soils derived from them contain some alkali even though they may be well drained. Generally speaking, the principal factors contributing to the alkali accumulation in soils can be summarized as (1) the aridity of climate; (2) the high salt content of the parent rock from which the soils are derived; (3) a high ground-water level; and (4) a high rate of evaporation during long dry summers that causes the capillary rise of water and salts to the surface.

The fine-textured soils deposited on the lower, more nearly level parts of the fans have very slow surface drainage, and in such areas salts are most likely to occur in excessive quantities. None of the streams on the west side of the area have channels that extend to the San Joaquin River; consequently, the floodwaters are absorbed on the more level slopes and retained there until removed by evaporation and transpiration. Salts contained in the floodwaters must remain in the soils. This accumulation has continued through years of alternate flooding and drying and has taken place particularly in soils of the Lethent and Levis and, to a lesser extent, in the soil of the Oxalis series.

In some parts of the area, alkali accumulations have increased because irrigation and seepage from irrigation canals have raised the level of the ground water. Continued evaporation from such areas has caused an accumulation of strongly alkaline salts at or near the surface. Soils immediately adjacent to the main canals have a higher concentration of salts than those farther away from the canals.

The quantity and kind of salts in irrigation water may be important in the development of alkali accumulations in soils. The soluble salt content of the irrigation water differs according to the source. In this area, the largest acreage is irrigated by water from the San Joaquin River and Fresno Slough through a system of canals; a large area is irrigated by water pumped from deep wells; and a relatively small acreage is supplied during flood season with water from the small intermittent streams that drain the foothills. Irrigation water from various sources was tested for content of soluble salt, and the results of the chemical analyses are given in table 9 in the section on Water Supply and Irrigation. It will be observed that well water is relatively high in salts as compared with samples of San Joaquin River water taken from two canals. Irrigation for a period of years with well water relatively high in salts, followed by irrigation with San Joaquin River or other water relatively low in salts, may result in a significant lowering of soil permeability, particularly in the heavier (finer) textured soils of the area.

A total of 563 soil samples, taken from 170 soil profiles, was tested for alkali content and the results recorded during the survey. These alkali determinations appear on the map in blue figures in the form of a fraction. The enumerators of the fractions show the percentage of salts in the surface soil, and the denominators, the average percentage of salts in the profiles to depth of sampling. A blue dot near a fraction designates the place where a sample was collected. Three or four or

more samples were collected from a soil profile at various depths, depending upon the number and thickness of the various soil horizons or layers.

The legend on map sheet 3 shows five grades of alkali concentration and how the grades are based on established ranges of the average percentage of salts in the whole profile and on the percentage of salts in the surface soil. The boundaries separating the various grades are shown by broken or continuous blue lines.

For shallow-rooted crops, there is little difference in production between soils free of alkali and the same soils slightly affected, but for deep-rooted crops a greater difference in yields would result. Soils moderately affected with alkali produce a noticeably lower crop yield than soils free or only slightly affected; and, in areas where salt accumulation is moderately strong, yields are generally low even from shallow-rooted crops. Moderately strong salt accumulations definitely indicate a serious condition. In these areas, the surface soil may be only slightly or moderately affected, but the subsoil is strongly affected. Most areas in which strong salt accumulations occur are not cultivated but are used principally for pasture.

The type of natural vegetation, character of crop growth, and certain structural features of the soil are general indicators of the degree of alkali concentration. In making soil surveys, these indicators are checked and correlated with tests taken to find the percentage of total salts in air-dry samples. The salt content in the soil samples is determined by use of the modified Wheatstone bridge, according to the procedure as set forth in the Soil Survey Manual (*6*).

The methods of preventing the accumulation of alkali in irrigated areas vary with the factors which have caused its accumulation. In general, preventive practices involve (1) the development of adequate drainage; (2) the avoidance of excessive use of irrigation water; (3) the lining of canals to prevent seepage; and (4) the use of good quality of irrigation water. The methods of reclaiming alkali soil depend upon the kinds of salts present and the soil that is to be reclaimed. The several factors to be considered in alkali reclamation (*4*) are: (1) Composition of the soluble salts; (2) drainage conditions; (3) composition of irrigation waters; (4) nature and content of the minerals of the soil; and (5) content of replaceable sodium in the soil. The fact that a soil may have a strong content of "alkali" does not necessarily prohibit successful reclamation and utilization; however, the character of the soil profile and the probable crop-producing ability of the soil when free of alkali should be considered before the reclamation is undertaken. Of paramount importance for successful alkali reclamation is the establishment of permanent and adequate drainage.

WATER SUPPLY AND IRRIGATION

The low annual rainfall in this area makes irrigation necessary if crops are to mature and produce a reliable income. In an area having less than 10 inches of rainfall, dry farming is more of a gamble than a sustained enterprise.

At the time of survey, only the basin soils and about 40 percent of the acreage on the fertile alluvial fans were supplied with irrigation water. Gravity water, supplied by the San Joaquin River through a

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system of canals, is used to irrigate the basin and basin-rim areas, and water from a number of recently developed deep wells is used to irrigate a considerable acreage of the soils on alluvial fans (pl. 2, *B*). Most of the alluvial soils of the area are tillable where they are not too strongly affected by alkali, and they would be productive if water were available.

Irrigation engineers, in the year 1869 or thereabout, decided that the junction of the San Joaquin River with Fresno Slough (the point where the river reached the center of the valley) was a strategic site to head a canal that would irrigate a large area of west-side lands. Several years later, the main canal, now known as the San Joaquin and Kings River Canal, was completed as far north as Los Banos, and by 1882 it had been extended to Crows Landing (in Stanislaus County). The outside canal paralleling the main canal was constructed about 1896, and the San Luis Canal system that irrigates a large part of the Santa Rita flood plain in the northern part of the area was completed in 1914. A system of canals was started near Firebaugh in 1919 or thereabout, but this was not completed until 1926. During the same period, other canals were constructed on the east side of the river and also farther south in the vicinity of Tranquillity.

At the time of survey, the San Joaquin and Kings River Canal and Irrigation Company, Inc., distributed water to approximately 48,000 acres in the Mendota Area. Water for general crops is delivered to the farmer at a flat yearly acreage rate. The rate differs according to the differing water requirements of the crops. A crop requiring a large amount of water, such as rice, has a higher rate than grain for example. An adequate supply is generally available, but it is certain only between October 1 and April 15. Approximately 21,000 acres are supplied with water through the facilities of the Firebaugh Canal Company, a mutually operated company. The Tranquillity Irrigation District, mutually operated, supplies water to about 14,000 acres in the vicinity of Tranquillity. Approximately 4,000 acres in the extreme southeastern corner of the area is furnished irrigation water by the James Irrigation District on a mutually operated cost basis, the rates being the same as for other irrigation districts in the vicinity.

Electrically driven deep-well turbine pumps supply irrigation water to about 85,000 acres of land lying below the 325-foot contour level. This extension of irrigation in the Mendota Area is rather recent and covers an area previously used mainly for sheep pasture. Depth to water generally ranges from 200 to 300 feet; the average lift is about 275 feet. Well depths vary from 900 to 1,600 feet. The wells are in operation from 10 to 11 months each year, and one well with a flow of 1,200 gallons a minute will irrigate approximately 600 acres.

The quality of water delivered by the wells is not particularly good because most of the ground water is highly gypsiferous. More than 60 percent of the total water residue consists of calcium and magnesium sulfates. Analyses of well water and canal water from the San Joaquin River from several selected locations are given in table 9. In the main, the well water, although not the best, had only slightly affected the soils or crop yields up to the time of survey.

TABLE 9.—*Chemical analysis*[1] *of selected samples of irrigation water used in t*

Source of sample	Location of sampling place	Mineral content (parts per mi			
		Calcium	Magnesium	Sodium	Chloride[2]
Wells:					
No. 1	NE¼ sec. 14, T. 13 S., R. 13 E	40	28		37
No. 2	SE¼ sec. 18, T. 13 S., R. 14 E	279	188		1,250
No. 3	SE¼ sec. 18, T. 13 S., R. 14 E	83	20		789
No. 4	SW¼, SW¼ sec. 35, T. 13 S., R. 12 E	18	18	298	85
No. 5	Center, sec. 22, T. 13 S., R. 12 E				3,240
No. 6	Middle south line, sec. 26, T. 13 S., R. 12 E	18	11	279	67
Canals:					
No. 1	NW¼ sec. 9, T. 13 S., R. 14 E				
No. 2	NW¼ sec. 7, T. 13 S., R. 14 E				

[1] Determinations reported by University of California or by Twining laboratories, Fresno, Cali

[2] Chloride content is average of three samples. Well No. 5 had too high content of sodium cl

Construction work on the Central Valley Project, a comprehensive and large-scale plan to distribute a more uniform and higher quality supply of water to the Sacramento and San Joaquin Valleys, was well under way at the time of survey. With its completion, a large part of the irrigation water from the San Joaquin River will be shifted from the Mendota Area and other west-side areas to other parts of the valley. Water from the San Joaquin River will be diverted by the dam near Friant (in Madera County) and distributed to the east side of the valley. When the project is completed, areas on the west side of the valley now irrigated by water from the San Joaquin will be irrigated by water from the Sacramento River instead. According to one plan, the water from the Sacramento River will be pumped to the foothills on the west side of the lower part of the San Joaquin Valley and from there transported by a high-line canal to the vicinity of Mendota. Under this plan, the cost of irrigation water to the farmer probably will be lower than that of the present supply; but, more important, delivery will be more constant and the water will be of a higher quality than that obtained from wells in the Mendota Area.

EROSION

Soil erosion is a natural process of removal of soil and soil material and is determined by conditions of slope, soil, vegetation, climate, and land use (*9*). Normal erosion takes place in an undisturbed environment and may result in land-building as well as land-destroying processes. It may be beneficial in the accumulation and deposition of fertile soil materials in alluvial fans and valleys, or it may be destructive in the removal of soil materials more rapidly than they are formed through natural soil-forming processes. The area of Rough broken land illustrates severe normal erosion.

When land is cleared, cultivated, burned over, irrigated, or overgrazed, the normal erosion may be so much accelerated that it destroys the natural productivity of the land.

Sheet erosion washes layers of the soil from the surface of the land and is frequently accompanied by the formation of small channels. Evidence of sheet erosion may be obliterated in the ordinary processes of cultivation. Little evidence of destructive erosion may be apparent until the subsoil or other underlying material is exposed.

Gully erosion is the formation of drainage channels of such size and number that they interfere with tillage operations and, in severe cases, with the grazing of livestock.

The slope of the land and the type of vegetative cover are highly important to erosion. A good sod forms a mat over the surface which holds the soil particles together, reduces the impact of rain water, and diminishes the velocity of water moving over the surface. Bare, overgrazed, or cleanly cultivated surfaces are most easily eroded.

In the Mendota Area, eroded areas were classified and studied concurrently with the soil mapping. The sloping upland Kettleman soils include areas where accelerated erosion from intensive sheep grazing is a very real problem. The Kettleman soils are easily washed away, and the parent bedrock is relatively soft and shattered, particularly along fault lines, where gullies readily develop. In many places, so much of the surface soil has been removed by sheet erosion and accompanying destructive gullying that the grazing value has been greatly reduced.

The control of erosion in these upland areas is difficult because of the grazing habits of the sheep, low rainfall, and the system of leasing the sheep range. The sheep range is leased, usually by the year, to roving bands at a fixed rental per acre and is grazed clean. The operator has no permanent interest in the land. Turning the sheep onto the range as soon as the first rains of the fall or winter have started the grass is detrimental because sheep graze the vegetation closely and there is little opportunity for natural reseeding. Deferred time of grazing would be most effective in improving pasture by allowing the grasses to get a good start and form seed before being grazed off. Care should be taken in bedding down the sheep to prevent packing the soil and the total destruction of vegetation. Bedding grounds should be moved frequently and wherever possible to areas that are not likely to erode. In the past, these upland areas have been good sheep range and with care they can be restored.

Although the nearly level soils on alluvial fans are not eroded significantly by rainfall, they are easily gullied under careless irrigation. This is especially true of Panoche and Panhill soils. Drops that will reduce scouring and deepening to a minimum should be installed in irrigation ditches.

MORPHOLOGY AND GENESIS OF SOILS

Soil is the product of the forces of weathering and soil development acting on the parent material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point depend on (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life in and on the soils; (4) the relief, or lay of the land; and (5) the length of time the forces of development have acted on the material. The effect of climate, and its influence on soils and plants, depends not only on temperature, rainfall, and humidity but also on the physical characteristics of the soil or soil material and on the relief. The relief, in turn, strongly influences drainage, aeration, runoff, erosion, and exposure to sun and wind.

A uniform relief of gently sloping and coalescing recent alluvial fans is characteristic of the west side of the San Joaquin Valley. The broad plain area is bordered on the west by the relatively short and somewhat older fans that lie at the base of low-lying foothills of the Diablo Range or by flat-topped terraces like those that occur north of Little Panoche Creek.

The Mendota Area has a hot climate. The annual rainfall of less than 10 inches comes during mild winters; the summers are long, dry, and hot. Only minor variations in precipitation and temperature occur over the entire area.

On the uplands, terraces, and alluvial fans, the limited cover of range grasses dries up late in spring or early in summer. Most of the rank growth of tules and swampgrasses that formerly covered the basin area has been removed by cultivation or otherwise replaced by a mixture of weeds and grasses.

West-to-east cross sections through the area (see fig. 2), beginning at an elevation of 1,000 feet on the western boundary, show a rapid drop in elevation from the upland soils within the first 2 miles, and then a very short but relatively steep area of older alluvial fans.

The broad, confluent Panoche Creek alluvial fan extends eastward on a downward gradient of less than 1 percent for about 20 miles and then joins the flat basin and San Joaquin River floodplain area. Surface features of the very gentle slopes are the result of stream activity both past and present. The sudden breaks in topography along Panoche Creek and Little Panoche Creek channels are exceptional.

The valley as a whole is a great structural trough or basin that previously contained a large body of water. Alternate periods of upheaval and subsidence were accompanied by intervals of erosion and deposition, especially along the western border. Early depositions are generally considered to have been marine, during the early and middle Tertiary. During the later Tertiary and Pleistocene, when the valley was supposedly outlined by the growth of the Coast Range, the marine deposits were covered either by deposits that were laid down in succeeding bodies of fresh waters or by alluvial sediments that were distributed over them after they were exposed by elevation and erosion. The present valley floor has been built up by deposits from streams, or from fluctuating lakes that are dependent upon streams, and is composed of eroded materials transported from the drainage areas of the surrounding mountains.

Under arid conditions like those of this area, the composition of parent rock is an important factor in determining soil characteristics. The rocks of the Diablo Range, from which all except the basin soils of the area have been derived, are classed geologically as a series of sandstones, shales and conglomerates of Cretaceous and earliest Tertiary (Eocene) age. Some influence from the slightly calcareous and metamorphosed Franciscan formation is evident in the soils north of Little Panoche Creek. In that area, the soils are not so calcareous and do not contain so much gypsum as the soils further south that are derived entirely from the highly calcareous and gypsiferous Cretaceous rocks.

The soils of the basin are composed of alluvium, for the most part derived from the rocks that form the eastern upland boundary of the valley. These rocks are composed mostly of granitic and metamorphosed sedimentary and igneous material of pre-Cretaceous age. At the north and south ends of the valley, they are overlain by a series of Tertiary sediments of Miocene or Pliocene age (*7*).

The soils of the area are Pedocals developed under the general process of calcification (*5*). According to the Soil Association map of the United States (*14*), the well-drained, well-developed soils are included with the Desert soils; however, intensive study may show that these soils developed in a very dry (Mediterranean) climate may be sufficiently different from the typical Desert or Red Desert soils to be included in a new soil group, such as a more basic counterpart of the Noncalcic Brown soils group.

The soils in the Mendota Area can be classified according to the zonal, intrazonal, and azonal orders and groups, but most of them fit the intrazonal or azonal orders better than they do the zonal. Normal zonal soils of a region must have been in place long enough to have allowed the soil-forming processes to express their influence fully; the relief must be gently undulating, not flat or hilly; there must be good but not excessive or poor drainage; the parent materials must not be of extreme texture or chemical composition; and there must not be excessive erosion. In the Mendota Area, the Lost

Hills, Los Banos, and Ortigalita series are included in the zonal order or group.

Intrazonal soils may have moderately developed profiles, but one or more local factors—such as poor drainage or strong concentration of salts—dominate forces that tend to develop the zonal soil characteristics of the region. In this group are the Kettleman, Oxalis, Levis, Lethent, Willows, Temple, Merced, Rossi, and Traver series.

Azonal soils show little profile development because of their youth, the condition of their parent materials, or their relief. This group includes the alluvial Panoche, Panhill, and Columbia soils, which are the most productive in the area.

The soils have been placed in six groups that roughly coincide with the natural physiographic divisions of the area. The first group, soils developed from consolidated bedrock materials, is represented only by the Kettleman, the upland soil series commonly found along the western edge of the southern San Joaquin Valley. The Kettleman are primarily upland soils, calcareous, and light yellowish brown or light brownish gray in color, derived from sandstones and shales. The fine-textured Kettleman soil types are derived from argilliferous, fine-textured sandstones rather than from the shales that usually give rise to fine-textured soils. Kettleman soils have been classified as Rendzinas (*14*) and appear to have too high a lime content for zonal soils. The western boundary of the Mendota Area lies along the contour line marking an elevation of 1,000 feet. At higher elevations farther west, there is an increase of rainfall, and soils with pedalferic characteristics are more in evidence.

The following is a detailed description of Kettleman silty clay loam collected in an area of hilly relief.

1. 0 to 6 inches, light brownish-gray or pale-brown, calcareous, friable silty clay loam readily crumbled to a soft granular mass. Soil is porous with many small root holes and insect borings.
2. 6 to 15 inches, light brownish-gray highly calcareous silty clay loam with appreciable quantities of segregated lime. Faint vertical cracks in the dry soil give rise to a weak prismatic structure.
3. 15 to 31 inches, light brownish-gray highly calcareous silty clay loam containing a considerable amount of gypsum. This horizon is slightly more compact and the small irregularly shaped aggregates are noticeably stained with colloids. Only a few roots reach this depth, and the material is rarely moistened by rain.
4. 31 to 60 inches, yellowish-brown, soft, argilliferous, fine-textured sandstone, becoming firmly consolidated with depth. Gypsum crystals in varying quantities are usually associated with segregated and disseminated lime carbonate.

The second group, soils developed from old unconsolidated terrace material, is represented in this area by soils of the Los Banos series. These soils are characterized by light reddish-brown or light brown friable profiles that are usually calcareous throughout. They are confined to a relatively small area along the edge of the foothills north of Little Panoche Creek and occur at elevations of from 300 to 1,000 feet. The Los Banos appear to be one of the zonal soils of the area. The relief is gently undulating except on the steeply sloping escarpments or sides of the terrace, and vegetation and biological activity are typical of the well-drained sites of the area. The parent terrace material is somewhat mixed. It was deposited on top of sedimentary rock and varies from only a few inches to as much as 15 to 20 feet in thickness.

A representative profile of Los Banos clay loam, undulating and rolling, is given in the following description.

1. 0 to 5 inches, light reddish-brown or light-brown, calcareous, friable, clay loam. It is easily penetrated by roots and water and has a weak granular structure. When moist, the soil becomes more red in color.
2. 5 to 20 inches, reddish-brown, slightly more compact, calcareous clay loam. The semifine subangular blocky aggregates are coated with colloidal stains, and appreciable amounts of both segregated and disseminated lime are present. Moisture penetration is facilitated by numerous well-preserved root holes and insect borings.
3. 20 to 47 inches, brownish-gray, moderately compact clay loam that is highly calcareous. Soil density sharply reduces porosity. The firm, subangular blocky aggregates are visibly stained with dark colloidal material. Small rounded gravel is usually present throughout the profile, mostly in the deep subsoil. The gravel is generally lime-coated, and in places it is closely packed and weakly cemented together.
4. 47 to 72 inches, reddish-brown, calcareous gravelly clay loam terrace material, frequently cemented into a conglomeratelike mass. This material is underlain at variable depths by consolidated sedimentary Cretaceous and early Tertiary rocks.

The third group is made up of soils developed from older alluvial fan materials. Two members of this group of secondary Pedocalic soils, the Lost Hills and the Ortigalita, are represented. They occupy short, somewhat more sloping, older fans of pronounced hummocky microrelief. Both are noncalcareous in the surface soil but highly calcareous in the moderately compact subsoil. The two series are related in age and mode of formation but differ in parent material and profile. The Ortigalita soils have developed mainly from materials from the reddish Los Banos soils of the terraces, and they have a reddish color. The Lost Hills soils are grayish brown, as they have developed mainly from materials outwashed from grayish Kettleman soils of the uplands.

Profile characteristics of Lost Hills clay loam, very gently sloping, are described as follows.

1. 0 to 7 inches, grayish-brown noncalcareous clay loam, brittle and crumbly, that breaks to a friable weakly granular structure. This layer is neutral in reaction, low in organic-matter content, and moderately permeable to roots and water.
2. 7 to 16 inches, a light grayish-brown, intermittently calcareous, moderately compact clay loam abruptly underlies the surface layer. Internal drainage and root penetration are retarded.
3. 16 to 27 inches, transitional to a grayish-brown calcareous light clay, moderately compact and only slowly permeable to roots and water. This material breaks to an irregularly blocky structure.
4. 27 to 42 inches, light-brown compact material containing an appreciable quantity of segregated lime specks abruptly underlies the layer above. A definite pattern of vertical and horizontal cracks has developed, which gives rise to firm blocky structural units when the soil is disturbed. The aggregates are heavily stained by colloidal material.
5. 42 to 72 inches, yellowish-brown, stratified, calcareous sandy clay loam, coarser textured than the horizon above and more friable. Roots and water do not readily penetrate to this material because of the slowly permeable horizons above.

The fourth and most extensive group in this area, soils of the recent alluvial fans and river flood plains, includes the Panoche, Panhill, and Columbia series. The Panoche and Panhill soils are very closely related in mode of formation and parent material, but they differ slightly in color, profile development, and geographical position. The Panoche, a long-established series that occurs extensively in earlier surveys (*3*) is somewhat younger and less advanced than the

Panhill series in profile development. The Panhill series comprises soils occupying slightly older fans that have reached a stage in development between that of the recent Panoche soils and the moderately developed Lost Hills soils. The Panhill surface soil is brownish gray or yellowish brown, noncalcareous, and friable. The lower subsoil is characterized by a definite zone of lime accumulation that indicates a more advanced stage of profile development than that of the Panoche. There is considerable evidence that the differences among the Panoche, Panhill, and Lost Hills series are primarily due to age.

The following is a detailed description of Panoche clay loam, the most common soil type of the Panoche series.

1. 0 to 17 inches, light brownish-gray, calcareous, friable clay loam, moderately permeable to roots and water. When dry, the soil develops irregular surface cracks and breaks into fine clods if cultivated; it is easily puddled and very sticky when wet.
2. 17 to 42 inches, a gradual transition to light brownish-gray calcareous clay loam, friable and moderately easily penetrated by roots and moisture. Where the Panoche soil borders Oxalis silty clay, moderate amounts of gypsum and some segregated lime are present.
3. 42 to 72 inches, the soil above grades into a light brownish-gray stratified clay loam that may contain a small quantity of gypsum in addition to moderate amounts of lime. Roots and water penetrate to this depth. The clay loam is occasionally stratified by medium- or coarse-textured sediments that contain appreciable quantities of segregated lime and crystalline gypsum.

The Columbia soils are the only soils in the area that occupy a recent floodplain position immediately adjacent to the San Joaquin River. Following is a profile description of Columbia loam.

1. 0 to 21 inches, light grayish-brown noncalcareous loam that is highly micaceous and friable, has a relatively low organic-matter content, and is nearly neutral in reaction.
2. 21 to 44 inches, a gradual transition to a light brownish-gray noncalcareous fine sandy loam, micaceous and streaked with rust-brown mottlings, and slightly basic in reaction. This layer is moderately easily penetrated by roots and water.
3. 44 to 72 inches, light-gray micaceous fine sand that is noncalcareous and loose. Rust-brown mottlings are more intense than in the material above, mainly because the soil at this depth is more frequently saturated by recurrent ground water.

Layers in this soil vary in thickness and are not distinctly separated by sharp boundaries. The entire profile is easily penetrated by roots and water.

The fifth group, soils of the valley-basin rims, includes the Oxalis, Levis, Lethent, and Willows series, which fall in the category of halomorphic intrazonal soils that have formed under the influence of salt concentrations. They occur on the outer edges or lower parts of alluvial fans that are occupied at higher elevations by the Panoche soils. The soils in these four series are calcareous and gypsiferous and normally contain moderate to strong accumulations of soluble salts. They differ in stage of profile development, in color, and in drainage.

The Oxalis soil is associated with the slightly higher lying Panoche, but it is somewhat darker in color and its subsoil normally contains more salts and gypsum. The Levis soil is similar to the Panoche in a number of respects, but it differs in having a high content of salt that gives rise to a distinctly fluffy surface soil. The Lethent soil is

apparently older than the Oxalis or Levis. It has a moderately compact subsoil and, except for moderate to strong concentrations of salts, is similar in stage of development and other characteristics to the Lost Hills soils.

The Oxalis, Levis, and Lethent soils do not appear to have developed under conditions brought about by a naturally high water table. Their saline character has probably developed over a period of time through their being flooded briefly and recurrently by the moderately saline water from Panoche and Little Panoche Creeks. The Willows soil has developed from parent material similar to that of the other soils in this group, but it occurs in a basin position, is poorly drained, and in most places is affected by a frequent high water table.

A description of a representative profile of Oxalis silty clay follows:

1. 0 to 13 inches, brownish-gray calcareous silty clay, slowly permeable to roots and water. Coarse blocky structure, firm when moist, very hard when dry, and sticky when wet.
2. 14 to 32 inches, brownish-gray calcareous silty clay underlies the surface soil after a gradual transition. It is similar to the surface soil but contains some concentrations of gypsum and is slightly lighter colored.
3. 32 to 72 inches, gradation to brownish-gray calcareous silty clay containing considerable segregations of gypsum. The soluble salt concentration is high.

The sixth group, soils of the valley basin, includes a number of closely related soils that are intimately associated in a complex soil pattern. There are four soil series in the valley basin, including members of the Temple, Merced, Rossi, and Traver series. All of the soils are derived mainly from granitic sediments that originate in the Sierra Nevada Mountains on the east side of the valley. The relationship of soils, as outlined by Kellogg (*5*), would place these soils in the intrazonal group of imperfectly or poorly drained soils.

The Temple soils are derived from alluvium originating mainly in the Sierra Nevada that has been deposited in depressions or partially enclosed basin areas where poor drainage prevails a greater part of the year. The original rank cover of tules and watergrasses is responsible for their dark color and the rather high organic-matter content. Improved artificial drainage will probably initiate a new soil-forming cycle for the Temple and other dark-colored basin soils of the area. The first evidence of the new cycle will be a decreased content of organic matter and a resultant lighter gray surface color. If the water table is lowered sufficiently and held at the lower level for a long period of time, the gray mottling in the subsoil will be replaced by a browner color. A more friable subsoil possibly will evolve and with it a corresponding increase in root penetration of the subsoil.

The Rossi soil, like the Temple, is derived largely from granitic sediments laid down in partially enclosed basin areas. It usually contains a strong concentration of soluble salts, and its subsoil is dense.

The Traver soil is calcareous throughout, and except for an occasional lenslike limepan in the subsoil, is moderately penetrable. It is derived from granitic alluvium, and small isolated ridges of sandy textured Traver soils are scattered throughout much of the area occupied by the Merced soils. The isolated ridges occupied by the Traver soil mark the banks of old minor streams that once traversed the basin area.

The following is a profile description of Merced clay (adobe), a type representative of the basin soils.

1. 0 to 6 inches, dark-gray noncalcareous clay that forms an adobe structure on drying. The soil cracks into large blocks, often 12 inches across; but when wet, it swells and becomes very sticky. This material is gritty, slightly micaceous, and nearly neutral in reaction.
2. 6 to 22 inches, dark-gray, compact, calcareous clay with characteristic lime specks. Surface cracks extend into this horizon and give rise to a very coarse prismatic structure. The structural aggregates are well-developed and visibly stained with mineral and organic colloidal material. Root and water penetration are definitely retarded.
3. 22 to 50 inches, olive-gray, highly calcareous, moderately dense clay containing a considerable amount of coarse grit and mica. A variable quantity of crystalline gypsum, together with segregated lime, may also be present. The soil is massive in place but breaks into subangular blocks that are smaller than the surface blocks and heavily coated with colloidal and rust-brown iron stains.
4. 50 to 72 inches, light-brown or dull olive-gray (depending upon prevailing ground-water conditions), calcareous, sandy clay loam; highly micaceous and contains variable amounts of lime nodules. This material is generally rust-brown mottled from a recurrent high water table and is similar to the substrata underlying most of the dark-colored basin soils of the area.

LABORATORY STUDIES [14]

All samples for laboratory analyses were air-dried and screened through a 2-millimeter sieve. Soil aggregates were crushed with a rubber-tipped pestle, and gravel and stones larger than 2 millimeters were rubbed relatively clean. The sieved material was thoroughly mixed and aliquot parts used for the laboratory analyses.

A mechanical analysis was made of each surface soil sample by a proximate method in which a weighed sample of the sieved soil is shaken overnight in distilled water to which ammonia has been added as a dispersing agent. The sands are separated from the silt and clay by wet-sieving through a 300-mesh sieve, and then dried, weighed, and reported as total sand separate. The suspension of silt and clay that passes through the sieve is made up to one liter, shaken, and sampled by means of a pipette at time intervals to give effective maximum diameters of coarse silt at 50 microns, of fine silt at 5 microns, of clay at 2 microns, and of colloidal clay at 1 micron. The results of the proximate analyses were used only to check the field textural classification of surface soils and are not included in this report.

Several soil profiles were selected for a more complete study. Mechanical analyses of samples from these profiles were made by the modified International method in which a weighed sample of sieved soil is pretreated with hydrogen peroxide and hydrochloric acid to remove, respectively, organic matter and carbonates. After washing free of electrolytes, dispersal is effected by shaking overnight with distilled water to which sodium oxalate has been added. The sands are separated from the silt and clay by wet-sieving through a 300-mesh sieve, and are then dried and weighed to determine the total amount of sands. The suspension of silt and clay is sampled by means of a pipette at time intervals to give effective maximum diameters of coarse silt at 50 microns, of fine silt at 5 microns, of clay at 2 microns, and of colloidal clay at 1 micron. The results of these analyses are given in table 10.

[14] This section prepared and analyses made by E. P. Perry, Division of Soils, University of California.

TABLE 10.—*Mechanical analyses of several soils of the Mendota*

Soil type and sample number	Depth	Total [1] sand (2 mm.–0.05 mm.)	Coarse silt (0.05 mm.–0.005 mm.)	F (0.0 0.0
	Inches	*Percent* [2]	*Percent*	
Letbent silty clay:				
579901	0–14	17. 6	30. 9	
579902	14–30	33. 0	42. 6	
579903	30–48	18. 3	34. 5	
579904	48–72	38. 6	34. 9	
Merced clay (adobe):				
579919	0– 6	11. 6	26. 2	
579920	6–22	16. 0	27. 5	
579921	22–50	21. 1	29. 1	
579922	50–72	38. 8	38. 4	
Kettleman fine sandy loam:				
579983	0– 7	77. 0	12. 7	
579984	7–22	74. 7	14. 1	
579985	22–30	65. 6	13. 4	
579986	30–60	71. 4	12. 8	
Panoche fine sandy loam:				
579994	0–18	69. 9	12. 9	
579995	18–27	32. 9	41. 6	
579996	27–60	58. 5	22. 7	

[1] Sands include fine gravel and consist of particles ranging from 2 millimeters to 0.05 millimete gravel, coarse sand, medium sand, fine sand, and very fine sand were not determined.

[2] Percentages are reported as separately determined. Because there is minor experimental percentages deviate slightly from a total of 100.

In this area, which is dominated by calcareous soils, a markedly increased amount of clay is obtained in mechanical analysis when the soil is pretreated with hydrochloric acid. The lime carbonate apparently acts as a cement that forms small aggregates of the finer clays. By the proximate method of analysis, these aggregates fall in the silt group rather than the clay. The removal of lime carbonate by hydrochloric acid gives a decreased silt and an increased clay content. In one instance, a subsoil sample contained gypsum in a concentration sufficiently high to prevent one pretreatment followed by washing from removing all gypsum, and a second pretreatment followed by washing was given. The second treatment successfully removed the gypsum so that the soil sample did not flocculate in the sedimentation cylinder.

In table 11, moisture equivalents, carbonates, and pH values of soils from the Mendota Area are given. Moisture equivalents were determined by the standard method, in which 30 grams of saturated soil are subjected to a force of 1,000 times the force of gravity in a centrifuge. The moisture retained is reported as a percentage of the oven-dry weight of the soil. A few soils were sufficiently impermeable to prevent the water from being thrown out by the centrifugal force, and it remained on the surface of the soil. In such cases the moisture equivalent was repeated with the usual moisture-equivalent cups, but waxed paper liners were added to the sides of the cups to allow better drainage. The moisture equivalent represents approximately the normal field-moisture capacity of the soil, or the amount of water that is held in the soil after a heavy rain or an irrigation where drainage downward is free and uninterrupted.

Determinations of pH values were made by the Beckman pH meter, using 50 grams of air-dry soil wetted to saturation and contained in a tall 4-ounce bottle. Carbonates were determined on all of the soils having a pH value greater than 7.0. These were made by the McMiller method in which the soil is treated with standardized hydrochloric acid until effervescence ceases and the amount of acid used in the reaction is determined by back titration with a standarized base. The amount of acid used is assumed to be equivalent to the amount of calcium carbonate present in the soil. It is recognized that this method involves certain errors, particularly where sodium carbonate is present, because the total carbonate is calculated as calcium carbonate.

This is an area of relatively fine textured soils, and the moisture equivalent values are correspondingly higher than in many other places in California. The bottom lands tend to have rather impermeable subsoils, as is indicated by water on the surface of samples after centrifuging. With paraffined paper liners inserted in the sides of the centrifuge cups, drainage is facilitated, and the amount of water retained after centrifuging decreases to an extent that probably closely approaches the normal field-moisture capacity of the soil. For most of the soils of this area, crops must be adapted to the fine textures and high water-holding capacities.

The pH values are almost all basic and reflect the influence of the calcareous parent materials and the dry climate. At the immediate surface they are less basic than in the subsoil because of both the greater amount of organic matter near the surface and the washing of soluble salts into the subsoil by the meager rainfall. Recent al-

TABLE 11.—*Moisture equivalents, carbonates, and pH values for soils of the Mendota Area, Calif.*

Soil type and sample number	Depth	Moisture equivalents: Standard method	Moisture equivalents: Cups with waxed-paper liners	Carbonates [1]	pH
	Inches	*Percent*	*Percent*	*Percent*	
Lethent silty slay:					
579901	0–14	29.8			7.3
579902	14–30		27.4	3.1	8.4
579903	30–48		24.7		8.2
579904	48–72		19.5	1.0	8.4
Traver fine sandy loam:					
579905	0–3	20.2		3.0	7.5
579906	3–17	14.5		7.1	8.3
579907	17–37	11.1		7.5	8.6
579908	37–60	5.1		.5	8.2
579909	60–72	22.2		.8	7.8
Temple silty clay:					
579910	0–9	40.0			5.9
579911	9–27	38.8		1.7	7.9
579912	27–45	(2)		2.3	8.4
579913	45–58	30.9		2.7	8.4
579914	58–72		21.2	2.3	8.5
Rossi clay loam:					
579915	0–8		28.3	3.1	8.8
569916	8–22		44.4	2.6	9.9
579917	22–48		22.3	2.8	9.3
579918	48–72		24.4	4.1	8.3
Merced clay (adobe):					
579919	0–6	37.9			7.3
579920	6–22	36.6		3.2	8.0
579921	22–50		38.3	7.0	8.4
579922	50–72	22.2			7.8
Willows clay:					
579923	0–16	41.4		1.8	7.9
579924	16–50		45.0	1.5	8.4
579925	50–70		23.9		8.4
Oxalis silty clay:					
579926	0–14	32.8		1.0	8.1
579927	14–32		46.8	2.0	8.6
569928	32–72		43.9	.5	8.8
Panhill silt loam, very gently sloping:					
579933	0–10	22.5		.2	7.2
579934	10–24	25.0		1.1	7.9
579935	24–60	24.9		.6	8.1
579936	60–72	21.5		1.2	7.8
Levis silty clay:					
579937	0–4		33.5	1.4	7.9
579938	4–10	38.5		2.2	8.5
579939	10–35		49.8	1.6	8.1
579940	35–60			1.3	8.1
Ortigalita clay loam, very gently sloping:					
579945	0–11	22.1			7.2
579946	11–23	22.5		.7	7.7
579947	23–36	21.3		1.6	7.9
579948	36–46	14.0		4.0	8.2
579949	46–60	7.2		1.0	8.4

See footnotes at end of table.

TABLE 11.—*Moisture equivalents, carbonates, and pH values for soils of the Mendota Area, Calif.*—Continued

Soil type and sample number	Depth	Moisture equivalents		Carbonates [1]	pH
		Standard method	Cups with waxed-paper liners		
Panhill clay loam, very gently sloping:	*Inches*	*Percent*	*Percent*	*Percent*	
579959	0–11	23.7			7.1
579960	11–27	22.4		1.0	7.8
579961	27–60	22.0		.7	7.7
579962	60–72		22.3	1.5	7.7
Lost Hills clay loam, very gently sloping:					
579963	0–7	31.5		.5	7.2
579964	7–16	31.0		.2	7.8
579965	16–27	26.9		1.1	7.9
579966	27–42	28.7		1.5	7.7
579967	42–60	26.5		1.1	7.8
Los Banos clay loam, undulating and rolling:					
579968	0–5	24.3		2.7	7.8
579969	5–11	23.8		4.8	8.3
579970	11–20	25.9		3.2	8.5
579971	20–47	26.1		12.6	7.9
579972	47–72	29.6		6.8	8.0
Panoche silty clay:					
579973	0–17	21.1		2.5	7.8
579974	17–42	22.1		2.4	8.0
579975	42–72	22.7		2.7	7.9
Columbia loam:					
579976	0–21	14.6			6.4
579977	21–44	5.8			6.6
579978	44–72	2.8			6.4
Temple silty clay loam:					
579979	0–11		31.7	.6	7.1
579980	11–26		40.1	1.9	8.3
579981	26–39		39.8	1.8	8.5
579982	39–60	20.8		10.0	8.1
Kettleman fine sandy loam, hilly, eroded:					
579983	0–7	14.2		2.0	8.1
579984	7–22	13.9		3.1	8.2
579985	22–30	21.5		15.5	8.6
579986	30–60	20.3		13.8	8.5
Kettleman silty clay loam, rolling, eroded:					
579990	0–6	26.6		1.9	7.7
579991	6–15	29.4		1.6	7.8
579992	15–31	38.2		.7	7.9
579993	31–60	31.3		1.7	7.9
Panoche fine sandy loam:					
579994	0–18		14.4	1.8	7.8
579995	18–27	21.5		2.0	7.8
579996	27–60	16.8		2.3	7.9

[1] Percentages for carbonates involve some error, particularly when sodium carbonate is present, but give an approximate measure of the carbonate content of the soil and usually of the calcium carbonate or lime that is present. The occurrence of sodium carbonate (black alkali) is infrequent in the Mendota Area.

[2] Water on surface of soil after centrifuging.

luvial soils such as the Panoche show little change, however, in either pH or lime content with depth. The least basic profile is one of the Columbia loam, which occurs on granitic alluvial material that originated on the east side of the San Joaquin Valley. It does not contain lime and is, in fact, very slightly acid, having pH values ranging from 6.4 to 6.6.

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SOIL MAP

MENDOTA AREA - CALIFORNIA

SHEET NO. 1

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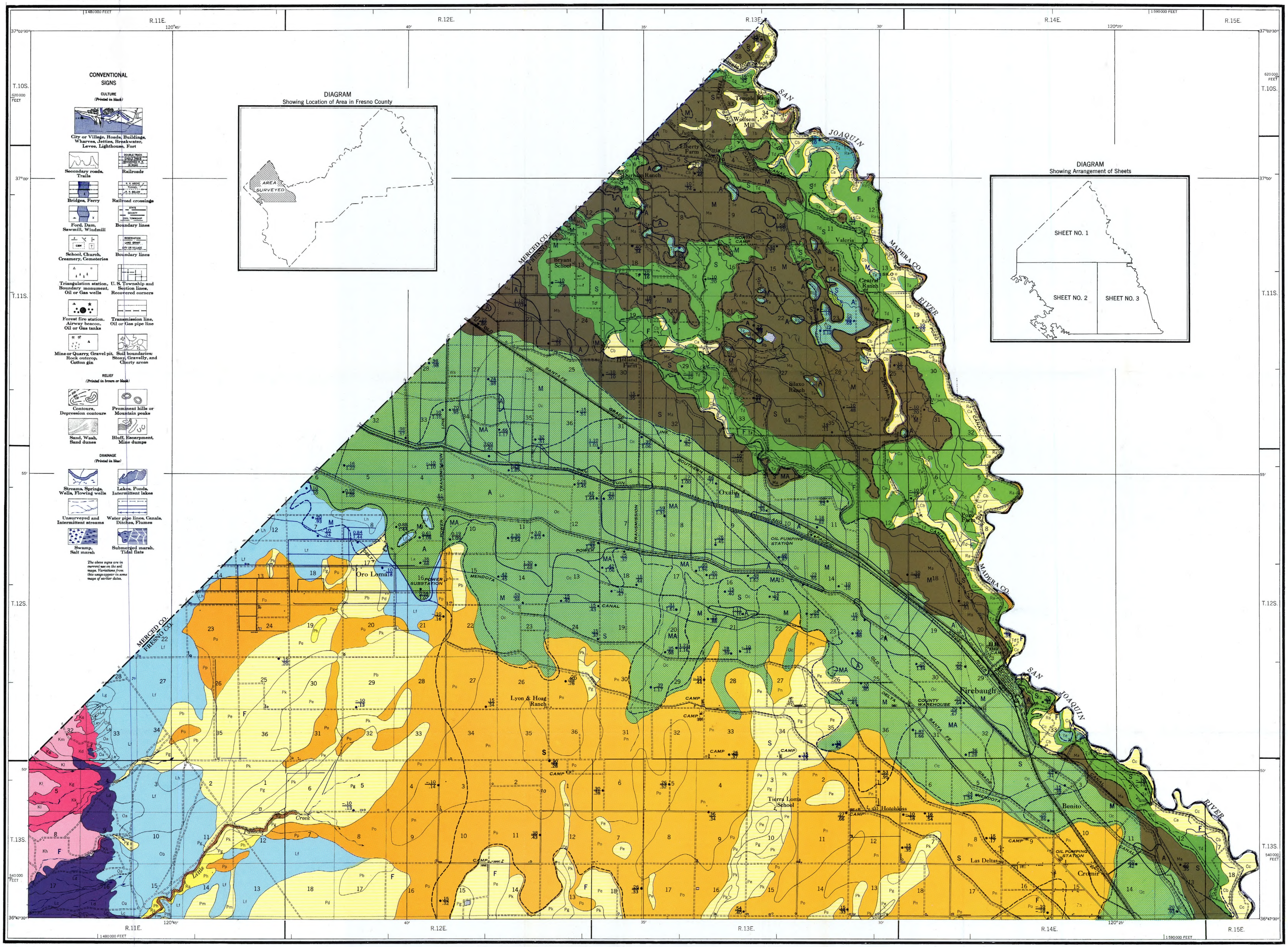
AGRICULTURAL EXPERIMENT STATION



J. Kenneth Ableiter, Chief Soil Correlator.
W. H. Allaway, Chief Analyst, Soil Uses and Productivity.
Correlation and inspection by R. C. Roberts, Principal Soil Correlator, Far Western States.
Soils surveyed 1940 by Frank F. Harradine, in Charge, and R. A. Gardner, L. G. Rooke, and E. A. Knecht, University of California.

Scale 1:63,360

1 ½ 0 1 2 Miles

5000 0 5000 10000 Feet

See Sheet No. 2 for Alphabetical Legend and Sheet No. 3 for Alkali Legend and Color Grouping.

Base map compiled by the Cartographic Division, Soil Conservation Service, USDA, from USGS topographical quadrangles with revisions from 1942 aerial photographs. Soil survey mapped on 1920 USGS topographical quadrangles. Polyconic projection adjusted to 1927 North American datum. 10000 foot grid based on California (Zone 4) rectangular coordinate system.

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UNIVERSITY OF CALIFORNIA
AGRICULTURAL EXPERIMENT STATION

SOIL MAP

MENDOTA AREA – CALIFORNIA

SHEET NO. 2

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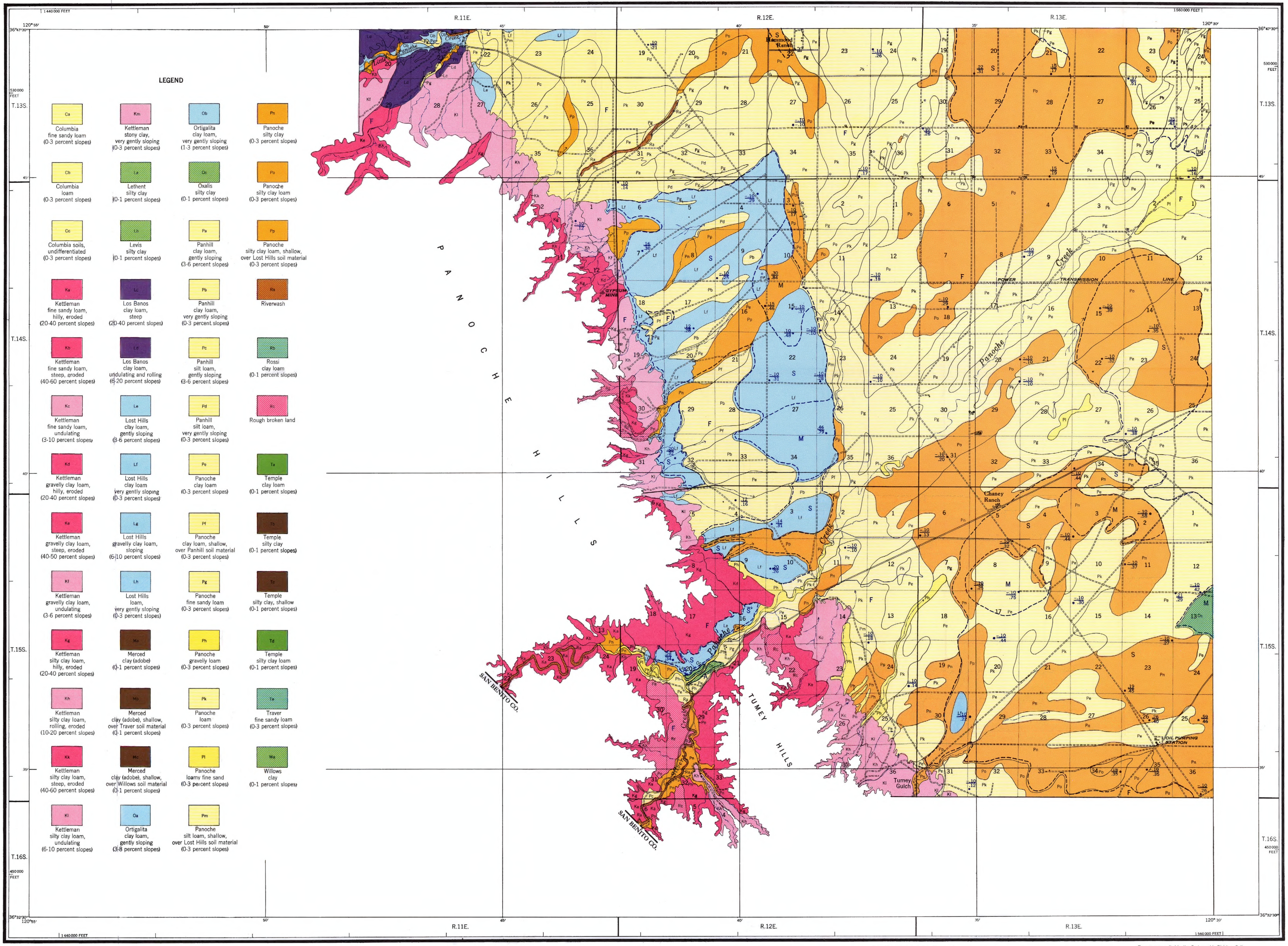
SOIL CONSERVATION SERVICE



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SOIL MAP

MENDOTA AREA - CALIFORNIA

SHEET 3

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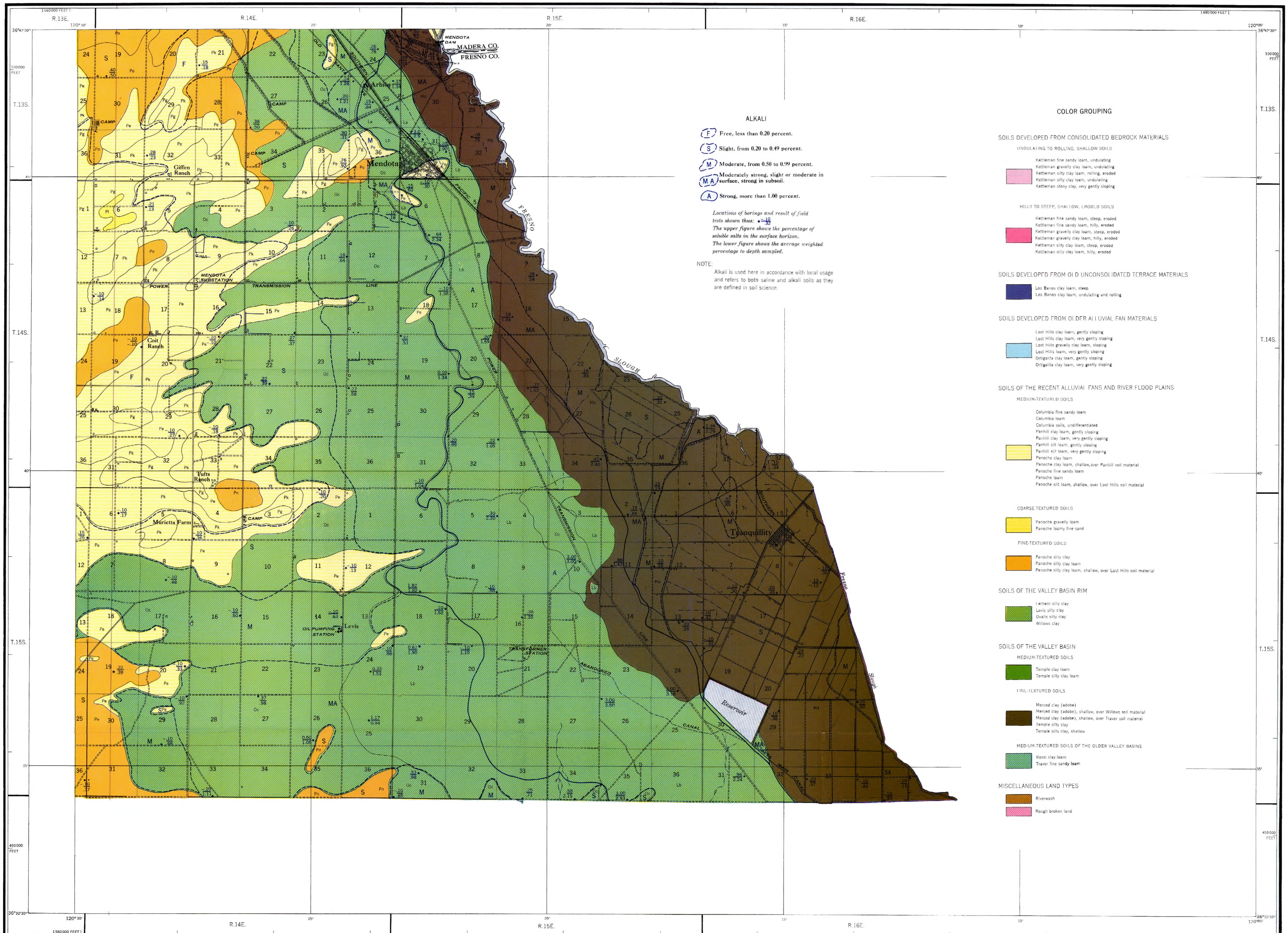
AGRICULTURAL EXPERIMENT STATION



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1 ½ 0 1 2 Miles

5000 0 5000 10000 Feet

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